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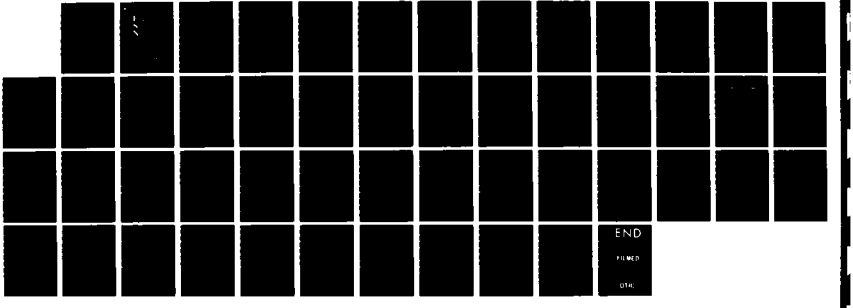

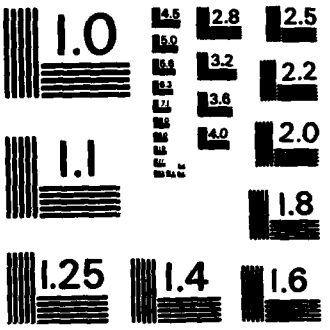

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ESN Invites Letters to the Editor

ESN publishes selected letters related to developments and policy in science and technology in Europe and the Middle East or to interactions between the US and Europe and the Middle East in science and technology.

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Biotechnology in France
Status and Prospects ..... Claire E. Zomzely-Neurath 499

This article provides an overview of France's "Development of Biotechnologies" program, which attempts to foster cooperation between public organizations and private industry.

Research at the FRG's Institute
of Biotechnology ..... Claire E. Zomzely-Neurath 501

West Germany's Institute of Biotechnology develops biotechnological processes and contributes to the research on treatment of solid and liquid wastes. Work now focuses on microbial degradation of biopolymers, conversion of substrates with biocatalysts, and biological treatment of wastewaters.

10th Meeting of the International Society
for Neurochemistry ..... Claire E. Zomzely-Neurath 502

The tenth meeting of the International Society for Neurochemistry was held in Riva del Garda, Italy, from 19 through 24 May. The presentations covered areas such as molecular neurobiology, post-translational modification, neurotransmitter receptors, neuropeptide processing, and specific macromolecules in cell-cell interactions in the nervous system.

Chemistry

Electrodeposition Phenomena in Molten Salts ..... Kurt H. Stern 503

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Computer Sciences

MILDAP: A Distributed Array Processor for
Real-Time Signal Processing ..... Charles J. Holland 504

The UK military, in collaboration with the firm International Computers Ltd., has been developing a highly programmable digital array processor called MILDAP. Capable of operating in excess of 300 million operations per second and occupying less than a cubic foot of space, MILDAP is conceived for a range of real-time signal processing applications in avionics.

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The University of Hamburg is the center for a small, well-funded, multidisciplinary marine research program studying the air-sea interface. This article discusses the program's funding and staffing, and examines research on wave damping and remote sensing.

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European Science Notes (ESN) is a monthly publication with brief articles on recent developments in European scientific research. The publication is not intended to be part of the scientific literature. The value of ESN articles to Americans is to call attention to current developments in European science and technology and to the institutions and people responsible for these efforts. ESN authors are primarily ONRL staff members. Occasionally articles are prepared by or in cooperation with staff members of the USAF European Office of Aerospace Research and Development or the US Army Research, Development and Standardization Group. Qualified US scientists travelling in Europe may also be invited to write an ESN article.

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Biological Sciences

BIOTECHNOLOGY IN FRANCE: STATUS AND PROSPECTS

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1986 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

A mobilization program, "Development of Biotechnologies," was initiated in 1982 by the French government under the direction of the Ministry of Research and Technology, of which Mr. Hurbert Curien is the minister. The purpose of the program is to upgrade France in the biotechnology areas in order to make it more competitive with other European countries in terms of research and products. This article examines how that program is faring.

Organization and Funding

The Ministry of Research and Technology is presently reorganizing the mobilization program for sectors in which France lags behind other countries. These are microbiology, for which the problems are essentially training problems, and enzyme engineering. In the latter area, support will be provided for research on bioreactors. The industrial applications of bioreactors are emerging, and this is an area in which France is still behind other countries.

To focus efforts in basic research as well as in industrial developments in all areas, the Ministry of Research and Technology has recently created the following as part of the reorganization of the mobilization program:

1. A program council of 20 members appointed by the minister and including all those who take part in the development of biotechnologies. The council includes representatives of the technical and industrial communities, scientists belonging to the various organizations and research institutes involved, as well as representatives from the Ministries of Research, Agriculture, Industry, and Health.

2. A Directorate of Projects, whose task will be to translate the guidelines of the program council into goals. The program director will be the sole person in charge of carrying out the efforts required in the various domains (agrifood, pharmaceutical and chemical industries, logistic support to biotechnologies). He will be assisted by four delegates and a group of experts.

3. Implementation of cooperative programs with other European countries.

Several cooperative projects with a European dimension have been started for 1985-86:

1. Strengthening the ties between European teams working on joint research.

2. Setting up strain and gene banks in Heidelberg to be available to researchers and manufacturers. Several other countries already participate in this program.

3. Setting up a French-German industrial research cooperation to bring together public organizations and companies in the two countries.

Public research has been regrouped in four institutes:

1. The enzyme technology laboratory of Compiegne University (under private contract). This laboratory is concerned with the recycling of pyrimdine cofactors, hemoglobin with pharmacological applications, and enzyme electrodes.

2. The enzymology laboratory of the Toulouse National Institute for Applied Sciences, which is involved in the development of reagents for the agrifood industries (enzymatic hydrolysis of saccharose, enzyme fixation on corn cobs).

3. The National Institute for Applied Chemical Research, whose research has been oriented since 1982 toward the following areas: (a) bioreactors--production of new membranes for fermentation applications; (b) production of synthetic peptide intermediate compounds (amino acids, oligopeptides, phosphorylated derivatives); and (c) industrial contracts for the development of processes to produce organic acids through bioconverison.

4. The French Petroleum Institute, which is involved in the production of polysaccharides from methanol and the production of enzymes.

The present public research effort is estimated at $80 million and involves the large research organizations. In addition, there are subsidies under the

auspices of the mobilization program ($25 million since 1982) and loans from the National Agency for the Implementation of Research (ANVAR) and the Industrial Modernization Fund. These funds have helped considerably in biotechnology research by encouraging cooperation between public organizations and industrial firms. The greatest progress has been in the pharmaceutical sector. During 1984 alone, the four largest companies spent over $55 million for research and development:

1. Rhone-Poulenc (fermentations) and its Genetica subsidary (genetic engineering) created a company, Bio-Europe, in partnership with Sugar Union.
2. Aquitaine Financial Corporation for Hygiene and Health (SANOFI) invested large amounts in research on genetic engineering and fermentation (Elf-Bioresearch Center of Labege) and in the area of cell fusion and monoclonal antibodies through its Clin-Midy subsidary in Montpellier.
3. Roussel-UCLAF did research in the areas of fermentation, enzyme engineering, and genetic engineering.
4. Merieux Institute/Pasteur Institute did research on the production of vaccines.

Some newly created companies in the pharmacological domain are: (1) Transgene (genetic engineering) and Immunotech (immuno-diagnostic methods); (2) Clonatec (monoclonal antibodies); (3) Biosystems (immuno-enzymatic methods); and (4) Oris (*in vitro/in vivo* diagnostic procedures).

Examples of Cooperation

One example of close collaboration between the public and private sectors is the Intergene program. Several organizations are working jointly on this program: the Ministry of Research and Technology, ANVAR, The National Institute for Health and Medical Research (INSERM), the National Center for Scientific Research (CNRS), Biomerieux, Immunotech, and Transgene.

The Intergene program now has two priority orientations: research on the use of latex particles for rapid diagnostic methods and research on immunodosages with nonisotopic markers. These two orientations have the advantage of being material goals corresponding to actual needs in industrialized and developing countries. The research integrates the following: (1) seven Biomerieux research laboratories working on the Intergene program (immunochemistry, enzymology, radioimmunology, bacterial immunology, parasitic and viral immunology, monoclonal antibodies, and enzyme purification. The last two laboratories provide Biomerieux with increasing independence with respect to biological raw materials. There are also contracts with INSERM Unit 58 (Montpellier) and Unit 34 (Lyons) as well as with the CNRS unit in Solaize.

During the past year the Intergene program was focused on Elisa Seroimmunology, on the development of relevant instruments in cooperation with the Statice Company (Besoncon), on new methods using bioluminescence in hormone studies, and on research on latex particles to optimize their qualitative and quantitative utilization. The production of some reagents--expected to be marketed during this year--has benefited from the acceleration generated by the Intergene program.

The Intergene program has also improved the potential of Biomerieux in two developmental orientations: latex particles and immunoenzymology. The Intergene program makes it possible to increase the technological effort of traditional reagents and new technologies and to establish more cooperative programs between public and private French research teams. The aim of the program is to retain the competitiveness indispensable to an international market for French reagents.

In the field of agriculture (seeds and plants), many National Institute for Agronomical Research (INRA) laboratories are working to improve plants. Large companies such as Clause-Limagrain and Rhone-Poulenc-Agronomy are making large investments in agriculture research. The INRA research centers, the Pasteur Institute, CNRS, Elf, CDF-Chemistry (French coal mines), and Rhone-Poulenc are carrying out research on the symbiotic fixation of atmospheric nitrogen.

The agrifood sector, for which biotechnology is very important, has unfortunately not taken advantage of the recent developments in biotechnology. However, a few companies are engaged in some biotechnological research in the agrifood area:

1. Boussois-Souchon-Neuvesel (BSN), Gervain-Danone, Bongrain, Bel-ULN (Norm- and Dairy Fromancais), and Sodima Yoplait--dairy industry.
2. Pernod-Ricard and Moet-Henessey--beverage industry.
3. Jacquet-Durvi Bread--bread-making sector.
4. Roquette--corn by-products
5. CECA-Rousselet and the Lafarge-Copper group--additives based on corn and wheat intermediate products.

A program was set up in the energy sector and coordinated by the French Energy Management Agency to develop the use of agricultural and forest biomass. The production of alcohol from the biomass could be used as a full substitute for oil, thereby making use of agricultural by-products and providing an additional market for agriculture.

Conclusion

Meeting the requirements of modernization and industrial competition with resources and appropriately distributed efforts, while stressing the necessity of intensifying research in the industrial world, has been the weak point in French government policy. Thus the cooperative programs between industry and academia outlined above should help in increasing the number of new French biotechnology products as well as decreasing the time from basic findings to marketable products. Although their level of research is high, the French have lagged behind other European countries in that collaboration between public and private research, which has been proven to be very effective elsewhere.

8/19/85

RESEARCH AT THE FRG'S INSTITUTE OF BIOTECHNOLOGY

by Claire E. Zomzely-Neurath.

The general goals of West Germany's Institute of Biotechnology (IBT) are to develop biotechnological processes and to contribute to the treatment of solid and liquid wastes. Current research and development activities are focused on the following areas: (1) microbial degradation of biopolymers; (2) conversion of substrates with biocatalysts; and (3) biological treatment of wastewaters. The directors of these three units are Professors Sahm, Wandrey, and Soeder. The IBT, located in Jülich, evolved in 1977 from the former Institute of Botany and Microbiology and now has about 100 employees.

Microbial Degradation of Polymers

The IBT's studies of the utilization of plant residues consisting mainly of cellulose and hemicelluloses are directed toward the eventual production of metabolites of pharmacological or technical interest--for example, glucose, xylose, ethanol, amino acids, and methane. In order to develop and to optimize adequate biotechnological processes, the regulation and localization of important enzymes are being investigated in microorganisms capable of metabolizing plant residues. Of special interest are the enzymes, cellulases, and hemicellulases, that cleave the polysaccharides, cellulose, and hemicellulose into oligosaccharides or monosaccharides. Attempts are being made to increase the enzyme yields by mutant selection and by gene manipulation.

Bioconversion of Organic Compounds

Once biocatalysts are isolated and characterized, they should be used in the most economical way. For this purpose, processes from chemical engineering are adopted and specifically improved at the IBT for the proper handling of microbes or of purified enzymes.

Enzyme reactors are operated continuously not only with individual enzymes but also with coenzyme-dependent multienzyme systems. Target products are, for example, optically active organic acids like amino acids. In membrane reactors, the products of the reaction are continuously withdrawn, while the larger enzyme molecules are retained within the system by ultrafiltration membranes. Thus a continuing homogeneous catalysis is ensured.

Whole cells can be used as the catalysts for the exploitation of metabolic routes which lead from the substrate to the end product (e.g., an amino acid) in more than one step. They are held back in the reactor by membranes with larger pores than those described above--i.e., microfiltration membranes. The feed solution contains precursors of the target product that are available via chemical synthesis.

Product formation cannot always be uncoupled from microbial growth. For instance, in the case of ethanol production from glucose, the growing microbial cells are partially retained in the bioreactor in order to maintain a high catalyst concentration. This results in an increased yield in time and space and reduces retention time. For calculating the dimensions of bioreactors with a precision comparable to that obtainable with conventional chemical reactors, the quantitative determination of all decisive reaction parameters has to be as precise as possible, according to the scientists at the IBT.

Biological Wastewater Treatment

As an alternative to entirely bacterial processes, photosynthesizing planktonic algae can be used for biogenic aeration of flat, pondlike containers

in which bacteria oxidize sewage compounds. At the IBT, the interaction between suspended algae and bacteria is being studied under continuous flow conditions, especially as it depends on solar radiation, temperature, substrate concentration, pH, and retention time. The cooperation between algae and bacteria also facilitates the degradation of relatively persistent chemicals--e.g., of naphthalene sulfonic acids. This approach is under investigation in the treatment of residues of anaerobic fermentation. The tests are carried out in the laboratory as well as on the pilot-plant scale.

Since the biological treatment of wastewaters can also proceed without a supply of oxygen, strains of anaerobic bacteria which participate in the conversion of dissolved organic substances into methane are being isolated and investigated with respect to their metabolic reactions. Besides the work on pure cultures, the conversion of various substrates by defined mixed populations is being tested. After laying the groundwork for increasing the catalyst concentration in the anaerobic fermentation of wastewater with high organic loads, the scientists at IBT will focus on process technology. This involves, for example, the uncoupling of solids (catalyst) retention time from liquid retention time. In this respect, it will also be of value to know how the formation of cell aggregates can be favored, because the latter facilitates the retention of bacterial biomass and its partial recycling in the overall process.

Some of the recent research accomplishments of IBT are:

1. The scale-up to the industrial level of an enzyme membrane reactor developed by IBT for the production of pure L-amino acids (industrial production began in 1981).
2. Development of a technique for coenzyme regeneration in the continuous operation of reactor systems based on coenzyme-dependent enzyme. Successful industrial test runs have been made for reductive amination of L-keto acids to yield the respective L-amino acids at a level of 0.5 kg of product per day.
3. The scale-up to the industrial level of a process for ethanol production by the bacterium *Zymomonas mobilis*. Production was started in April 1983.
4. Planning, construction, and running of a pilot plant for microalgae production in Egypt.
5. Degradation of napthaline sulfonic acid with algae bacteria-mixed cultures.
6. Continuous treatment of a highly loaded wastewater from a cellulose factory by means of a mixed culture of bacteria.

Conclusion

Scientists at the IBT have made major contributions to biotechnology research since the formation of the institute in 1977. Furthermore, several basic research findings have already been adopted for use in industry.

8/19/85

10TH MEETING OF THE INTERNATIONAL SOCIETY FOR NEUROCHEMISTRY

by Claire E. Zomzely-Neurath.

The Tenth Meeting of the International Society for Neurochemistry (ISN) took place at Riva del Garda, Italy, from 19 through 24 May. The total attendance was about 900, with 780 preregistrations. The ISN meetings take place every 2 years in different countries as the membership is truly international in scope.

The scientific program consisted of 10 symposia covering a wide range of topics in neurobiology (Table 1) as well as oral communications, poster sessions, and round tables (workshops).

The most striking change in the topics covered at this ISN meeting was the number of sessions on the use of molecular biological methods including recombinant DNA (rDNA)--i.e., molecular neurobiology) in neurochemical studies. Many of the speakers were scientists whose training and experience were in molecular biology and who are now using the powerful techniques of rDNA to resolve problems in neurobiology that either cannot be answered or can be answered only with great difficulty by the usual neurochemical methods.

The subject of neuronal membranes, encompassing studies of ion channels and lipid metabolism, was also emphasized in the presentations. Sessions on neurotransmitter receptors, and studies of glial cell function and neuropeptides were more prominent than at previous meetings of the ISN. It was also evident from the presentations that tissue culture and immunological methods are being used more often in neurobiological studies.

Although the US scientists account for 46 percent of the total membership

Table 1

Symposia and Colloquia

Symposia

1. The Impact of Molecular Genetics in Neurochemistry
2. Neuronal Membranes: The Modulation of Lipid Metabolism and its Consequences
3. Functional Implication of Posttranslantional Modification in the Nervous System
4. Neuronal Membranes: The Role of Ion Channels
5. Meurotransmitter Receptors: New Approaches
6. Mechanisms of Axonal Transport
7. The Aging Brain
8. Molecular Aspects of Neural Development and Plasticity
9. Neuropeptide Processing
10. Specific Macromolecules in Cell-Cell Interactions in the Nervous System

Colloquia

1. Molecular Events Underlying Simple Learning and Memory Events.
2. Prostaglandins and Leukatrienes in Brain Function
3. Dynamic Aspects of Transmitter Storing Organelles
4. Recent Developments in the Study of Glial Cells
5. The Future for the Brain Graft
6. Environmental Neurotoxic Substances

of the ISN, the US representation at this meeting accounted for 27.5 percent of the total number of participants, with Western European countries contributing 53.3 percent. Scientists from Italy, France, West Germany, and the UK were the largest groups from the Western European countries, about twice the representation in the membership of the ISN. This means that there were a sizable number of non-ISN member attendees. The Eastern European countries accounted for 4.5 percent of the total number of participants, about twice as many as at past ISN meetings held in Western European countries.

Representation by Japanese scientists was very high, also 7.5 percent of the total. This large attendance by Japanese scientists is a recent phenomenon and has been reflected in their attendance at European meetings in all areas of scientific research, including biotechnology, pharmacology, etc.

Abstracts of the ISN meeting have been published in the *Journal of Neurochemistry*, Vol 44 supplement (1985) by Raven Press, New York; this is the official journal of the ISN.

For a detailed discussion of presentations at the conference, see ONR, London, conference report C-10-85, which you can order by filling out the return mailer inside the back cover of this issue.

8/19/85

Chemistry

ELECTRODEPOSITION PHENOMENA IN MOLTEN SALTS

by Kurt H. Stern. Dr. Stern is a researcher in the Chemistry Division, Naval Research Laboratory, Washington, DC.

A workshop on electrodeposition phenomena in molten salts was held at Imperial College in London on 8 and 9 July. The workshop was chaired by Professor Douglas Inman (Imperial College). The impetus for the meeting came from Dr. I. Ahmad of the US Army Research, Development and Standardization Group, UK, who was interested in bringing to- gether most of the workers in this field to report on recent progress and assess future prospects.

The US Army has a major interest in this field, since it is looking for ways of reducing metallic wear at high temperatures, such as those on the inside of gun barrels during firing. Ahmad was active in this field when he was at Watervliet Arsenal in New York; he was trying to electroplate tantalum-chromium alloys from molten fluoride baths. This method, worked out by Senderoff and Mellors at Union Carbide during the 1960s, is still the only way of electroplating most of the refractory metals. Its greatest drawback is that it requires a temperature of 750°C--too high for some applications in which the mechanical properties of the substrate are degraded. Nevertheless, there is still a good deal of work going on in this field.

Fundamental electrochemical studies were described by Dr. S.H. White of EIC Laboratories Inc. (US) for plating group VI A metals. Such voltametric studies should be beneficial in working out the mechanism of deposition processes. Related studies, but focusing on the melt-metal interface, were discussed by Dr.

F. Lantelme of the University Pierre et Marie Curie in Paris. He was particularly interested in diffusion processes which occur during alloy formation, a process known as metalliding. In this case a surface alloy is formed when a more active element diffuses into a less active one under an electrochemical gradient. Electroplating, the deposition of a uniform coating, and metalliding used to be considered separate processes, but Dr. P. Taxil of the Paul Sabatier University in Toulouse pointed out that the same process may occur either way, with metalliding predominating at high temperatures, and electroplating at low ones. The effect of overvoltage on coating structure was shown by Inman to be the result of its effect on nucleation density, which is extremely sensitive to overvoltage.

Several attempts were described to lower the plating temperature by substituting other salts for fluorides. The biggest problem is to find salts which can function as solvents and are not themselves reduced. Dr. D.J. Schiffrin at the University of Southampton, UK, has had some success with thiocyanides, and Dr. G.B. Ellis of the US Los Alamos National Laboratory described work on iodide melts. He emphasized the importance of choosing the proper solute for plating.

Chromium came in for a lot of attention, six papers being devoted to it. It is the only refractory metal which can be plated from aqueous solution, but until recently such coatings have been full of stress-induced microcracks, and thus not suitable for demanding applications. Dr. G.P. Capsimalis of the US Army's Watervliet Arsenal described the most interesting improvement in the process: alternate low contraction and high contraction chromium layers are plated from aqueous solutions by an automated system. In this way, crack-free chromium coatings have been prepared.

I described a novel process for electroplating refractory compounds from molten fluorides. Carbides of tantalum and tungsten were produced by simultaneously reducing a compound of the metal and carbonate. The metal and carbon react on the surface to form the carbide. Similarly, tantalum silicide was formed by simultaneously plating tantalum and silicon. The platings are hard and dense, and should be suitable as wear coatings up to 500°C.

The competition was also heard from. Physical and chemical vapor deposition (CVD) are both active fields, but they have their problems also, in spite of much greater efforts and a longer history. For example, CVD requires even higher temperatures than does plating from fluoride bath.

There was a consensus that efforts to lower plating temperatures should be increased since this would lead to increased applications. Considering that there are probably no more than two dozen molten salt electrochemists active in this field, compared to several hundred working on vapor methods, progress so far has been quite encouraging.

7/22/85

Computer Sciences

MILDAP: A DISTRIBUTED ARRAY PROCESSOR FOR REAL-TIME SIGNAL PROCESSING

by Charles J. Holland. Dr. Holland is the Liaison Scientist for Applied Mathematics/Computational Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on reassignment until December 1985 from the Office of Naval Research, Arlington, Virginia, where he is the Deputy Division Director of the Mathematical Sciences Division.

The UK military, in collaboration with the firm International Computers Ltd. (ICL), has been developing a highly programmable digital array processor called the MILDAP. Capable of operating in excess of 300 million operations per second and occupying less than a cubic foot of space, MILDAP is conceived for a range of real-time signal processing applications in the avionics environment. The first unit was scheduled for delivery to the Royal Signals and Radar Establishment (RSRE) this autumn, with 10 or more ultimately to be delivered. ICL's commercial plans for the MILDAP are currently unknown.

Scientists at RSRE feel that there are strong incentives for meeting a wide range of digital signal processing applications using a programmable approach based on a standardized processor architecture and language. A principal advantage, they feel, is the lowering of project technical risk, because the freezing of some system specifications can be postponed by keeping software options instead of making hardware commitments to algorithms.

This article describes the architecture and capabilities of the MILDAP and discusses its ability to satisfy a number of roles in the avionics real-time signal processing environment (speech recognition, radar signal processing, electronic support measures, image processing, etc.)

Background

The MILDAP architecture is not new; it is based on the ICL DAP, which was introduced commercially in the 1970s. The more recent Goodyear Massively Parallel Processor (MPP), built for the US National Aeronautics and Space Administration (NASA) for satellite remote sensing applications, utilizes a similar architecture.

The architecture of the DAP was briefly described in *ESN* 39-1:9-12 (1985). Instead of the 64×64 square array of the DAP, the MILDAP has a square array of 1024 processors (32×32). The MILDAP is a single instruction multiple data (SIMD) machine, which means that each one of the 1024 processors is doing the same operation at each time (unless disabled by an activity switch). The clock cycle time is 150 ns (compared to 200 ns in the DAP), and at each clock cycle a single bit operation is performed on each of the 1024 processing elements.

Each processor has 8000 or 16,000 bits of storage and is connected to its four nearest neighbors. Each processor has a 1-bit accumulator, a carry register, and an activity switch.

The DAP was not a commercial success. Perhaps one of the reasons for its commercial failure was the requirement to have continuously an ICL mainframe front end (and hence an expensive investment in ICL products). This difficulty has been solved with the MILDAP, which can be programmed by an ICL PERQ. (The PERQ is a minicomputer originally developed in the US.) However, once programmed the MILDAP can be disconnected from the PERQ and operated in a stand-alone fashion. It can then be reconnected to an ICL PERQ when software changes need to be made.

In addition to the number of processors, its much smaller size, and its capability to operate in a stand-alone fashion, the remaining essential difference from the DAP is its fast data input-output data buffering (up to 40 Mb/s). This last capability is especially important for its real-time applications.

Two programming languages exist: a high-level parallel form of FORTRAN called DAP FORTRAN and an assembler language for high efficiency. The bit serial nature of the DAP allows for unconventional methods to be used for the computation of certain functions. For example, a square root algorithm takes half the time of a multiplication; thus, unlike with most serial machines, the square root is not a function to attempt to avoid in the construction of algorithms. In general, particular attention to the DAP architecture must be given to derive very efficient algorithms. Fortunately, over the last 8 years, the British government has encouraged the use of the DAP. This has led to a wealth of experience with associated algorithm development for the DAP which will be transferable to the MILDAP.

Real-Time Signal Processing Applications

Over the last several years ICL and RSRE researchers have been investigating the ability of the MILDAP (using simulations on existing DAPs) to perform a wide range of real-time signal processing applications. This section describes some of those efforts, showing the ability of unconventional algorithms to overcome apparent difficulties in utilizing an SIMD machine (e.g., that algorithms with branching instructions cannot effectively utilize all processing elements efficiently).

A natural signal processing application for a distributed array processor is image processing since, in principle, images can be mapped directly into the array store and because the large number of pixel or data elements can be treated identically and locally (in that the output value of each pixel depends upon the value of its nearest neighbors). In fact, two other SIMD machines have been recently developed with image processing in mind: the NASA-supported Goodyear MPP for real-time signal processing of satellite images and the UK GEC Rectangular Image and Data Processing machine for both image and general data processing.

One consideration with the MILDAP is how to efficiently fit large picture data (say 64×64 to 512×512 pixel images) into the 32×32 MILDAP array store. The obvious solution would be a windowed mapping in which the images are cut into 32×32 regions and stored vertically within the processor arrays. Unfortunately, this technique is not optimum for many algorithms because at sheet edges, neighboring pixels can be in extreme memory locations on different planes. The suggested alternative is a crinkled mapping in which a pixel neighborhood is stored under each processing element. For example, in a 64×64 image the (1,1) processing element would contain the four pixels (1,1),

(1,2), (2,1), (2,2) in successive memory planes, etc.

It is very easy to see how the MILDAP will be very good at low-level image processing techniques like edge detection; the difficulty (which may be overcome) will be on higher level techniques like feature extraction, which do not have a pixel by pixel operation.

Another application that has been considered for the MILDAP is real-time speech recognition based on dynamic time warping methods both for the case of isolated and connected word recognition. Dynamic time warping procedures use dynamic programming principles to compute the goodness of fit between the input voice data and a number of sound templates stored in a digital vocabulary built up from previously recorded speech. Three approaches have been considered for the storage of the vocabulary in isolated word recognition: (1) each vocabulary word is stored with a node; (2) each vocabulary word is distributed across all processor nodes; and (3) distribution of each vocabulary word amongst N diagonally related nodes (rather than the 1 or N×N nodes of the first and second cases). The last method has been to have the highest theoretical throughput unless the vocabulary is large compared to N×N (over 600 in the case N=32), in which case the first method has the highest throughout.

Although not described in this article, radar and electronic support measures applications have also been analyzed for the DAP.

Conclusion

RSRE and ICL researchers are confident that the MILDAP architecture is an efficient one for solving a wide range of real-time signal processing applications. Full-scale distribution in the UK military of the current version is unlikely. Instead, the experience gained with the current version will likely be utilized in a future VLSI version of the MILDAP, and have one to two orders of magnitude improvement in terms of throughput over the current version.

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Material Sciences

MICROORGANISM INVOLVEMENT IN CORROSION OF METALS IN THE MARINE ENVIRONMENT--SOME UK RESEARCH

by C.P. Patrick Reid. Dr. Reid is a US Navy Commander in the Reserve Technology Mobilization Program of the Office of Naval Research.

Reports given at a recent international conference on biological-induced corrosion at Gaithersburg, Maryland, 10 through 12 June 1985, seem to indicate that the mainline corrosion community is just coming to realize that biology could significantly influence the chemistry of corrosion (*Science News*, July 1985). Research has now confirmed that sulfate-reducing bacteria and possibly other microorganisms are involved in corrosion. A real key to managing the problem of biocorrosion is first to recognize that biocorrosion can be a threat, and then to design systems and carry out testing and maintenance.

Considerable research is now being conducted in fundamental aspects of microbiology that relate to metal corrosion. Recently I visited several laboratories involved in biocorrosion research in the UK. This article indicates some of the current directions of investigations on biological involvement in corrosion of metals.

Hill & Associates

The extent of microbiological problems in marine environments was amply illustrated by Mr. E.C. Hill of E.C. Hill & Associates, whose research facility in Cardiff is primarily concerned with microbiological testing and advisory services to ship, oil and chemical, aviation, and metalworking companies worldwide. Most work is concerned with microbial contamination, spoilage, and/or corrosion, and often involves petroleum products and process water. Many of the company's activities involve solving problems for industry and monitoring microbial contamination. Workshops on basic microbial techniques for testing and monitoring are often given to shipboard personnel. Although the company does not currently engage in R&D, it plans to do so in the near future.

Many problems are encountered with lubricating oils on ships, most caused by bacterial contamination of aerobic *Pseudomonas*-like organisms. Results of such oil infection include degradation of additives, increased acidity of the oil, plugging of filters, and eventual pitting corrosion. Occasionally, sulphate-reducing bacteria become established if conditions become anaerobic, especially in ships that are out of operation for extended periods, leading to corrosion. Microbial problems with lubricating oils have increased over the past few years because of different

formulations and the presence of additives that often stimulate microbial growth. Additionally, chromates (toxic to microbes) are no longer added to cooling water, but rather nitrites are added which can provide nutrients for microbe growth and become a source of microbial contamination in oil.

Microbial contamination of engine oils in some cases has been severe enough to cause mechanical failure of engines. Most problems are found with low- and medium-speed diesel engines, which do not attain oil temperatures high enough to kill contaminating microbes. There appear to be fewer problems with steam turbine engines.

With greater demands for diesel fuels worldwide over the past several years, new diesel-type formulations produced by petroleum manufacturers are proving to be more susceptible to microbial growth, especially in ship engines, where additives are not usually economical as in aircraft fuels. Although *Cladiosporium* used to be a primary contaminant of fuels, most contamination is now bacteria and yeasts. This has proven to be an acute problem for diesel ships operating in the North Sea. Microbial contamination in fuels usually results in filtration problems, injector failure, and failure of coalescers. Attempts are being made to develop biocides that can sterilize the fuel system on a one-application basis on the short term (6 to 24 hours).

Hull corrosion of ships is occasionally a problem when cargos contain sulfur, e.g., sulfur-containing coal, where certain aerobic bacteria produce sulfuric acid leading to corrosion. An awareness is developing of the problem of sulfate-reducing bacteria in ships' bilges, where anaerobic conditions can develop. This condition can lead not only to corrosion but to dangerous levels of H_2S to personnel. A new biocide is currently being tested that appears effective against sulphate-reducing bacteria.

Hill's group has been very effective over the years in developing rapid detection techniques for microbial contamination in shipboard systems that can be used by personnel with little microbiological training.

In Hill's estimation there are several areas of fundamental research that are needed relative to microbiological problems on ships. First, the basic chemical characteristics of fuels are needed in order to understand why microbial growth is stimulated. Additionally, a very careful look at the characteristics of additives is needed to determine their effects on microbial growth.

Sheffield University

The research by Dr. Robert Edyvean's group in the Department of Metallurgy at Sheffield University emphasizes the processes that are caused by microbial corrosion and that lead to failure of metal components in marine environments. His group is actively involved in research on the effects of marine fouling on the corrosion of offshore structures. Although Edyvean has published considerable work on corrosion as affected by marine microalgae, his current research emphasizes the effects of biologically active environments on the susceptibility of metals to corrosion fatigue, fatigue that results from the combination of a corrosive environment and applied cyclic stress to produce failure of a metal by the development and growth of cracks. Although seawater is a corrosive medium and a major source of fatigue loading on steel structures, marine fouling can also influence corrosion of metals in several ways: (1) by creating differential aeration cells at the surface; (2) by producing corrosion-promoting metabolites, especially acids and H_2S; and (3) by stimulating anodic reactions.

Since corrosion fatigue appears to be considerably enhanced by microbially produced H_2S, studies are being conducted to determine the effects of H_2S on the enhancement of fatigue crack growth rates in the laboratory, but under conditions that attempt to simulate the marine environment, under both static and cyclic load conditions.

Edyvean indicates that more information is certainly needed on the relationship between the corrosion caused by marine fouling and the formation and growth of fractures. In his estimation, intensive research is required in order to determine quantitatively the levels of H_2S, O_2, pH, and other microbial metabolites at the interface between the metal and biofilm.

University of Manchester

Dr. E. Bellinger and his group at the Pollution Research Unit at the University of Manchester are addressing Edyvean's requirements by examining the microenvironment of metal surfaces when organisms are present. Specifically, they have developed microelectrodes for measuring pH and O_2 in biofilms on metal surfaces. Electrodes for measuring O_2 are approximately 25 μ in diameter and can be used in biofilms approaching 100 μ in thickness, whereas pH electrodes can be as small as 10 μ in diameter, allowing measurement in layers as thin as 20 μ to 25 μ.

In his estimation, information on pH and O_2 is critical in determining the effects of organisms on corrosion at a microscale level.

Dr. Mark White in the same unit has been studying microbial colonization and corrosion of metal surfaces under cathodic and noncathodic protection. Investigations using both scanning and transmission electron microscopy indicate that, when using visual characteristics, it is very difficult to distinguish between inorganic corrosion products and bacteria, especially on nonprotected surfaces. The combination of vital staining (acridine orange) and electron microscopy is being used to distinguish the two. Microscopy work also indicates that organic matter appears to be the first layer of material deposited on metal surfaces, which is then followed by microorganism colonization. Examination of initial colonization over the first few days shows that the organisms colonizing free-corroding (not cathodically protected) surfaces are different from those that are protected cathodically, with the latter surfaces supporting a more diverse microflora and microfauna.

University of Warwick

The interest in initial colonization by microorganisms on metal surfaces is shared by a number of research laboratories, with considerable emphasis on mechanisms of bacteria attachment. Dr. Madilyn Fletcher's research group in the Department of Environmental Sciences, University of Warwick, is primarily concerned with fundamental research in two areas of bacterial interaction with surfaces: (1) the mechanism of adhesion, and (2) the ways in which adhesion to surfaces alters the physiology of the organism. Although previous research has dealt with marine aerobic bacteria, current work involves aerobic bacteria *in situ* (freshwater) and laboratory work in defined media. Various environmental factors have been examined relative to the adhesion of bacteria in both single and mixed cultures. Effects of carbon source and nitrogen/carbon ratios as well as temperature and pH have been addressed.

Of particular interest is recent work with mutants of *Pseudomonas fluorescens* that have both better and poorer adhesion properties than the wild type. A "mucoid" mutant, with lesser attachment, produced an extracellular alginate lacking in the wild type. The mutant that demonstrated a greater ability to attach to surfaces lacked the alginate but had 40 to 55 percent less polysaccharide in the outer membrane lipopolysaccharide fraction. Further work will examine the surface characteristics of similar mutants and phenotypes of specific bacteria.

Considerable emphasis is now being given to the detailed properties of the surfaces and outer membrane of bacteria as possibly altered by the process of adhering to surfaces. Presently, the ability of attached bacteria to use radioactively labeled carbon substrate is being compared to that of free living bacteria.

Fletcher indicated that much more work needs to be done on the environment's influence on surface chemical groups of bacteria which then affect adhesion characteristics.

City of London Polytechnic

Although Dr. Christine Gaylarde in the Department of Biological Sciences, City of London Polytechnic, is also concerned with attachment by bacteria, her group is primarily working with the anaerobic bacteria and their relationship to metal corrosion. Although her research includes come applied aspects, fundamental research is examining the structure of the outer membrane of *Desulfovibrio* bacteria to determine its importance in the adhesion mechanism of this group of organisms. Consideration is being given to the uptake of ferrous iron and its relationship to binding of the organism to surfaces. *Desulfovibrio* is an anaerobic, dissimilatory sulphate-reducing bacterium which is able to induce the corrosion of ferrous metals in anoxic environments. Such characteristics have made this microorganism prominent in such problems as anaerobic metal corrosion and souring of oil deposits by biogenic hydrogen sulphide. The prevention of such problems often requires treatment with biocides.

In other, more applied studies, Gaylarde and her research group are examining the effect of mixed cultures of sulphate-reducing bacteria and non-sulphate-reducing bacteria on corrosion of mild steel. Although the exact reasons are unclear, the rate corrosion by *Desulfovibrio* is often enhanced by the presence of a non-sulphate-reducing bacteria such as *Vibrio*. The most probable explanation that has been put forth for the increased corrosion is an increase in the adsorption of *Desulfovibrio* in the presence of *Vibrio*. Additionally, the application of biocides is often less effective in inhibiting sulphate-reducing bacteria when other bacteria are present.

Gaylarde said that perhaps the most important avenue of research to pursue is an understanding of initial adhesion

of bacteria and the mechanisms involved in the buildup of biofilms on metal surfaces. This information is vital as a basis for an intelligent approach to devising preventive measures against microbial corrosion.

Gaylarde's laboratory is also developing a new immunological test for detection of sulphate reducers as a group. Such a test will offer a greater sensitivity and increased rapidity over current techniques used for detection.

British Petroleum

Several research groups at British Petroleum's (BP's) Research Center at Sunbury-on-Thames are involved both with problems of corrosion arising from sulphate-reducing bacteria and with adhesion mechanisms. Dr. Paul Rutter's group is conducting research on the adhesion of microbes on surfaces, with a primary emphasis on the quantitative description of short-range forces influencing adhesion. Special emphasis is being given to specific binding molecules and extracellular polymers. Such research is important to understanding early stages in microfouling of surfaces in marine environments and the microfouling of surfaces involved in distribution systems such as pipelines.

Dr. Barbara Crouch is conducting research related to the formation of microbially produced biofilms on metal surfaces and their subsequent effects on corrosion. Particular attention is being given to biogenic sulphide films formed on steel surfaces by an interaction with marine sulphate-reducing bacteria (such as the species *Desulfovibrio*) under anaerobic conditions. Although the presence of sulphate-reducing bacteria on steel surfaces in anaerobic conditions results in only relatively low rates of corrosion, subsequent exposure of the surfaces to aeration results in very high rates of corrosion, with pitting a common characteristic. The formation of a biogenic sulphide film on the steel surface influenced by the sulphate-reducing bacteria appears to be a crucial component of the corrosion process under aerated conditions. The production of sulphide by sulphate-reducing bacteria often occurs whenever wet oil or an oil product is stored and transported. It is further suggested that these organisms may be involved in corrosion of storage vessels. The bacteria present in the water phase may originate from ballast water or seepage, and their activity is stimulated by the presence of crude oil.

Corrosion scientists at BP are also using the AC impedance technique to evaluate the effects of microbial growth on the corrosion of steel surfaces.

Corrosion Inhibition and Macrofouling

Techniques that seek to inhibit corrosion related to microbial colonization obviously have effects on macrofouling processes as well. Dr. E.E. Williams' research group in the Department of Zoology at Sheffield University has been conducting research concerned with the effects of heavy metal pollution on the behavior and attachment of the common mussel, *Mytilus edulis*. Although much of their work is concerned with labile levels of metal ions that affect marine organism behavior and are biological toxic, it does provide information valuable to understanding macrofouling of metal surfaces. Their development of a bioassay for copper-impaired seawater using the plantigrades of *Mytilus edulis* could be useful for assaying other protection mechanisms for preventing macrofouling. They are currently pursuing research examining the macrofouling and corrosion of ship pipes which have been treated by various electrical field techniques.

In analyzing seawater for labile levels of heavy metals, they are using the potentiometric stripping analysis method, a valuable tool for determining parts per billion levels of ions.

Conclusion

Although several other research laboratories in the UK are involved in various aspects of biocorrosion, the investigations reported here represent the types of research that are being actively pursued in a field that is becoming increasingly important to the operation of metal-based vessels, structures, and systems in marine environments.

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8/5/85

RESEARCH AT DFVLR'S INSTITUTE FOR METAL RESEARCH

by Kenneth D. Challenger. Dr. Challenger is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until May 1986 from the Naval Postgraduate School, where he is Associate Professor of Materials Science.

As has been explained in previous *ESN* articles, the German Aerospace Research Establishment, DFVLR, has many different laboratories active in materials-related research. Their composite materials research was reviewed in *ESN* 38-6:316-319 (1984), and the work at the Institute for Structural Mechanics, Braunschweig, was updated in *ESN* 39-9: 466-467 (1985). The Institute for Metals Research (IMR), Köln, directed by Professor H. Bunk, is the principal site for research on both metallic and nonmetallic materials. Approximately 100 employees (80 percent funded by the Ministry of Research and Technology [BMFT]) are performing research (some of which is outstanding) in the following subjects: (1) microstructure correlations with mechanical properties, the theme of most of the research at IMR; (2) fracture mechanics; (3) spectrum fatigue; (4) stress corrosion cracking; (5) powder metallurgy; (6) high temperature materials; (7) engineering ceramics; and (7) a small contribution to West Germany's microgravity experiments.

This institute will play a critical leading role in West Germany's new 10-year program of advanced materials research to begin in 1986. The total expenditure over the 10 years is planned to be DM100 million (approximately $11 million).

Composite Materials

The research on composite materials, led by Dr. K. Schulte, was reviewed in *ESN* 38-6. The following is a summary of recently initiated projects.

A project on the effect of fiber and matrix ductility on the static and cyclic behavior of carbon fiber reinforced polymer matrices is producing some interesting results. Araldit LY556 and MY720 matrices from Ciba-Geigy (fracture strains of 5 and 1.3 percent, respectively) hardened with HT 976 have been used in conjunction with Toho Beslon carbon fibers Besfight HTA-3000 and ST-3 (fracture strains of 1.4 and 1.8 percent, respectively). Test specimens with various combinations of fibers and matrices have been evaluated. The

composites made with higher ductility fibers ST-3 always had a higher fracture stress and fatigue life from similarly constructed composites using HTA-3000 fibers. The highest strength and fatigue life occurred when the matrix was LY556 and MY720 mixed in equal proportions. This produced better results than a matrix of 100 percent MY720; however, tests on 100 percent LY556 have not been performed yet. The mixed matrix has a fracture strain of 4.5 percent, thus only small differences, if any, are expected. The lowest fracture stress (800 to 900 MPa) was measured for the composites made from MY720/HTA3000 (both low fracture strains). This increased to 1000 to 1050 MPa for MY720/ST-3 and further increased to 1150 to 1200 MPa for MY720-LY556/ST-3 composites.

Another new topic is Ott and H. Nowack's development of a "substructure" finite element analysis method to predict the cyclic stress strain behavior and the fatigue crack growth rate of carbon fiber reinforced composites. Their emphasis is on simplification techniques for the prediction of multiaxial fatigue loading. This is an extremely complex problem for anisotropic materials such as the fiber reinforced composites. The analyses, even with simplification, require enormous amounts of computer time. At present the researchers can calculate and predict the cyclic stress strain behavior, but a damage calculation (crack growth and life prediction) is not yet possible.

The other topics under investigation have not progressed significantly beyond those reported in *ESN* 38-6.

Metal-Matrix Composites

This work, also reported in *ESN* 38-6, seems to be winding up. The only active research is a very fundamental study of the interface reaction region between SiC fibers, which are used to reinforce a titanium alloy (Ti-6Al-4V) matrix. H. Dudek uses a highly focused electron beam Auger spectroscopy method. The samples examined were prepared by cutting the composite almost parallel to the fibers, thus artificially (geometrically) enlarging the reaction zone between the matrix and each fiber from 1 µm to about 10 µm. The composition and phases present in the reaction zone have been characterized. The first region in the reaction zone (nearest to the Ti-6Al-4V matrix) is homogeneous and has been identified as titanium silicide, Ti_5Si_3. The next region encountered in the reaction zone contains TiC particles embedded in the Ti_5Si_3. The number of the TiC particles increases near the SiC fiber until in the immediate neighborhood of the fiber only TiC is present. The researchers have used these results to explain the reaction processes which occur during the fabrication of the composite. Their interpretations of these reaction processes will be used to guide the future development of Ti-SiC composites.

The main problem with these composites is the loss of strength due to the degradation of the surfaces of the SiC fibers. An improvement in strength can only be expected if the degradation of the surface of the fibers can be stopped without reducing the adhesion at the interface. This means that a layer of TiC at the interface must be built up very early in the processing to prevent further diffusion of Ti to the fiber. This suggests that coating the SiC fibers with TiC prior to embedding them in the Ti matrix may be a successful procedure. This research is continuing.

For studying surface properties, DFVLR's IMR has an unusual facility that is particularly suitable for studies of fracture mechanisms. Dudek has built a surface analysis system that includes scanning Auger spectroscopy and x-ray photoelectron spectroscopy in the same vacuum system as a servo-hydraulic mechanical testing machine. Samples can be fractured by any predetermined loading sequence and transferred to either or both of the analytical instruments without ever leaving the vacuum. I believe that only one other similar surface analysis facility exists, and that is in Japan.

High Strength Al-Li Alloys

Work on these materials has been hampered by the reluctance of the suppliers, Alcoa and Alcan, to sell the materials at this point of their development. The suppliers claim now to have solved the problems of low fracture toughness and ductility in these materials, but test pieces representative of this "improved" material are slow in reaching the European research laboratories. (I heard this same story both at the Netherlands Aerospace Research Laboratory and here at DFVLR.) The researchers are anxiously awaiting the arrival of this new Al-Li material. (Alcan DTDXXXA should be available soon, but the XXXB alloy is still being held back. And Alcoa seems to be avoiding Europe).

Ceramics

Ceramics, led by Dr. J. Heinrich, is one of the larger programs (15 people) at the IMR, and it is growing.

The new materials research program for West Germany planned by the BMFT includes a very large effort on ceramics, and DFVLR will be a major participant in this program. For the past 10 years the researchers at DFVLR have been studying all aspects of Si_3N_4 ceramics for use in advanced gas turbines. Their work has included material development (powder production, additives, processing, molding, and thermal treatment); technology (pressureless and pressurized sintering, hot pressing, hot isostatic pressing [HIP], reaction bonding and joining); microstructural characterization; and the evaluation of mechanical properties. The relationship between microstructure and mechanical properties forms the basis for almost all of the research at the IMR.

Work is in progress on: (1) the evaluation of the sintering characteristics of powders produced by nitridation, vapor phase deposition, carbo-thermal reduction, and diimide precipitation (a new method); and (2) the relationship between mechanical properties after sintering and the purity, size, and shapes of these powder particles. The shape of the particles is very important in terms of how it affects the flow of the liquid phase (by capillary forces) during sintering.

The results of other experiments on reaction bonded Si_3N_4 indicate that the fractional porosity per se is not the main parameter which determines the fracture strength in reaction bonded Si_3N_4, but that size distribution of the pores is more important (the presence of very large pores is the major cause for reductions in fracture strength). High strength materials must have a homogeneous microstructure with a narrow pore size distribution and small pores. By optimizing the processing condition, reaction bonded Si_3N_4 was produced that had a 1250°C fracture strength of 320 MPa at a density of 2.5 g/cm^3. Liquid phase sintered Si_3N_4 which was hot isostatically pressed during sintering with Y_2O_3 as a sintering aid had a 1250°C fracture strength of 500 MPa.

From a technological viewpoint the researchers are trying to develop a fabrication method that combines a reaction bonded preform that is then hot isostatically pressed into its final shape. They have purchased a sintering furnace that can be heated to over 2100°C and pressurized to 100 atmospheres with N_2, thus preventing the decomposition of the Si_3N_4 during the high temperature reaction bonding treatment. This starting material has a density of about 2.6 g/cm^3 (78 percent of the theoretical density). Thus, the linear shrinkage during the HIP process is only 6 to 7 percent, enabling the production of complex shaped parts with close dimensional control (very important, as machining Si_3N_4 is very difficult and expensive). They have a patent on a sinter-canning technique which involves surrounding the reaction bonded preform with boron nitride powder, encapsulating the preform with "glass" (fused silica or vycor), and evacuating the glass can. These canning materials become ductile above 1800°C and will allow a HIP pressure of at least 200 MPa to be transmitted to the preform. The boron nitride prevents any chemical reaction between the Si_3N_4 preform and the "glass" can. This technique has been called the powder-bed-canning technique by DFVLR. They have also developed a sintered can technique for more complex shapes. The components are coated with a slurry (confidential composition) which is sintered to gas tightness. After HIPing, this layer can be removed by sand blasting. Complex shapes such as small rotors and turbine blades have been produced by this technique.

This work on Si_3N_4 for gas turbines is undergoing technology transfer to industry this year. Next year the researchers' focus will change to include SiC and fiber reinforced Si_3N_4 and SiC matrix ceramics.

The researchers in the ceramics group are young, enthusiastic, and may be the best ceramics group in a government laboratory in West Germany.

Powder Metallurgy Al and Ti Alloys

A 20 to 50 percent improvement in the notched fatigue strength of conventional 2024 and 7075 aluminum alloys has been shown when the materials are produced by powder metallurgy (PM) rather than ingot metallurgy (IM) techniques. The biggest gains to be made appear to be in the creation of new alloys by PM that cannot be produced by IM. Titanium PM alloys should provide much more economical production methods and use of rare raw materials, while at least maintaining the mechanical properties of IM materials.

Dr. Gunter Stanick has performed an excellent study (in conjunction with the US Air Force Wright Aeronautical Laboratories) on the factors that affect the characteristics of the thin oxide (Al_2O_3) skins present on the surface of all aluminum alloy powders. This work is a necessary step in understanding the effect of these skins on the mechanical behavior of powder metal Al (and Ti) alloys. A clever sample-preparation technique of electrolytically embedding the particles in nickel in order to prepare

thin foil samples for transmission electron microscopy (TEM) was developed. By using this method, he was able to use TEM to follow the oxide changes that occur during the compacting and extrusion stages of processing.

He found that the oxide skin is amorphous and typically only 500-nm thick on the particles. After hot pressing, the skin is partly separated from the particles but remains between the particles. During extrusion, the oxide skin may be broken up and dispersed in the direction of extrusion, but it remains in its original interparticle location transverse to the extrusion direction.

The oxide skin can behave in a very ductile manner during hot pressing and sintering unless specific steps are taken (embrittle the oxide by specific heat treatments). Unless the oxide is embrittled, it will not break up and disperse during extrusion, thereby leaving an oxide film at all original interparticle boundaries; this has a very undesirable effect on the mechanical properties. He has found that the Al-Li alloys are particularly susceptible to this ductile oxide behavior.

The work which is continuing on Al and Ti powder metallurgy is part of a cooperative research program (DM3 million per year) between Norway and West Germany. Staniek's work should provide some of the needed fundamental information regarding the strengthening (and degradation) mechanisms for these alloys produced by powder metallurgy. This is very important to the development of the new, rapidly solidified, high-strength aluminum PM alloys.

High Temperature Material

A new burner test rig for studying hot corrosion/oxidation of gas turbine materials was built in 1983. The rig is not novel, but it is the only one in West Germany. It is designed to test small specimens, not full cascades of blades. (The Netherlands Aerospace Research Laboratory has the only test rig capable of testing full cascades of blades or vanes.) The rig was purchased as part of a Norway-West German cooperative project and has been used initially for a joint program. Future work includes collaboration with the Royal Aircraft Establishment, Farnborough, UK.

Directionally solidified eutectic alloys have been developed for gas turbine blades and vanes. The coating system needed to protect these materials from oxidation and hot corrosion is under development and nearing completion. This coating work is confidential at present, but they claim to have solved the problems associated with matching the thermal expansion characteristics of the directionally solidified eutectic material.

This area of research is decreasing in activity at the expense of the composite and ceramic materials programs.

Spectrum Fatigue

The work on spectrum fatigue is headed by Nowack. This has been one of the largest and longest research projects at the institute. This is because the main objective in the design of new aircraft is to make them as light as possible without any loss of reliability. One step in meeting this goal is to develop reliable prediction methods for the initiation and growth of fatigue cracks. In conjunction with fracture mechanics methods, a generalized fatigue-life-prediction method is under development. In order to accurately predict fatigue damage, the prediction method must incorporate the nonlinearity of fatigue damage accumulation. This requires that the models be developed and verified using loading spectra that resemble actual loading conditions. Both fatigue crack initiation and propagation under realistic loading spectra are under study.

These results have shown that initiation of a crack can be accelerated by spectrum loading as compared to constant amplitude loading, but that the reverse may be true for crack propagation.

Excellent results of the prediction method have been obtained. These results and a description of the prediction methods were presented by Nowack at the Second International Conference on Fatigue and Fatigue Thresholds, University of Birmingham, UK, 3 through 7 September 1984.

In order to verify their prediction on specimens which simulate real structures, they are building a 100-ton by 20-ton biaxial testing rig. This, combined with the existing laboratory testing facility, makes this institute the best-equipped fatigue research center for aircraft applications in West Germany.

Al-Li alloys will be the subject of intensive spectrum fatigue testing in the near future (as soon as they can get some test material from Alcan).

Conclusion

The researchers at IMR are almost completely funded by the BMFT (very little contract work) and thus have more flexibility and opportunities to pursue more fundamental topics than their counterparts in other countries. Their research on composite materials (ceramic, metal, and plastic matrices) and

engineering ceramics is growing rapidly. IMR should be the most important European center for research on these materials as the BMFT begins its new 10-year plan for materials research in West Germany.

6/18/85

THE SPANISH INSTITUTE FOR CERAMICS AND GLASS RESEARCH

by Kenneth D. Challenger.

The Instituto de Ceramica Vidro (ICV) is Spain's only research center for ceramics and glass. Even though the institute is small (72 employees, of whom 35 are university graduates), some very good and interesting research is being performed on a few important topics. The director of ICV, Prof. Dr. S. de Aza, is leading a team of enthusiastic scientists in fundamental studies of multiphase tough ceramics (Dr. J.S. Moya) and piezoelectric materials (Dr. P. Duran), and more applied research on the coating of glass by the sol-gel process (Dr. J.M. Navarro), the production of low-cost glass and ceramics from industrial wastes, and the development of new analytical methods to be used for the characterization of ceramics and glass (Dr. F.J. Valle). The research by Moya and Duran is noteworthy and will be discussed in this article.

Organization and Funding of ICV

ICV was founded in 1965 as part of the Consejo Superior de Investigaciones Cientîficas (CSIC), the major funding body for scientific research in Spain. (For background on the CSIC, see *ESN* 38-6:336 [1984]). ICV moved to its present location in Arganda (about 20 miles east of Madrid) in 1971. The institute is divided into four departments: Ceramics, Glasses, Special Production, and Analytical Methods. The two departments of greater interest are Ceramics and Special Production because this is where most of the research is performed.

The financial support for the institute comes from many sources. The labor costs are supported almost entirely by CSIC, but it provides very little support for supplies and equipment; these must be covered by outside contracts. Local industry provides about 2 percent and the Comisión Asesore de Investigacion Científica y Técnica provides most of the remaining funding (15 percent). Small contracts (but very important to ICV) have been obtained from the Spanish-American Treaty (for collaborative research with Professor G. Thomas, University of California, Berkeley) and from another source (unknown to me) for collaborative research with Professor B.C.H. Steele, Imperial College, London.

Aza encourages his people to collaborate with other laboratories. In January 1986, Dr. Maribel Osendi is going to work with Dr. David Lewis for one year at the Naval Research Laboratory, Washington, DC. This is their first contact with the US Navy, and I hope that it leads to some long-term collaboration as I feel that there could be mutual gains from such collaboration. Moya spent 1 year with Thomas at the University of California at Berkeley, which led to their current collaborative research; this has certainly proved to be benificial to ICV (I am not in a position to judge what Thomas is getting out of the program, however). I know from my discussion with Aza that collaboration with scientists outside Spain is providing a significant and perhaps a critical input to their research. If the US wishes to promote the development of science and technology in Spain, the best method appears to be to provide funding for research that specifically involves collaboration with US scientists.

Overall Impressions

My overall impressions regarding Spanish research in the field of materials is that there are many good scientists and engineers performing high-quality research, but their efforts are not coordinated by anyone. If Spain itself hopes to gain from this research, then the government must provide some guidance as to which topics are more important to the development of Spanish industries and technologies. I was told that this is, in fact, beginning and that the government is setting long-term goals, but this was not obvious to me. I have heard Spanish government administrators talk of certain subjects as national priorities, but according to the scientists themselves, there is very little funding from the government to support research on these subjects. It would appear to be important for Spain to carefully select the topics it considers as having the greater effect on Spanish industrial growth before it formally enters the European Economic Community next January.

Two topics of very high interest to the investigators at ICV for future research are ceramics based on silicon

nitride and fiber (SiC and Al_2O_3) reinforced ceramics (probably the tough ZrO_2 mullite presently under development at ICV will be used as the matrix material). A very large amount of research has already been completed in Europe on the silicon nitride system, so I am not sure (and neither are they) what contribution they can make to the development of these materials. It seems that their personal interests, rather than the potential benefits to Spain, have influenced these decisions.

In the following sections I briefly review what I consider the better research projects at ICV.

Research at ICV

One of the main themes of the research at ICV is the study of the relationships between microstructure and properties in engineering ceramics. The importance of the relationship has been clearly shown for metals and now ceramicists have appreciated that this will be important for ceramics also.

As with metals, the final microstructure is strongly influenced by the properties of the starting materials and every step involved in the fabrication of the final product.

Phase Diagram Determinations

Aza has developed phase diagrams for several binary, ternary, and quaternary oxide systems. Before any new material is developed, the phase diagram for the system should be known. Many of these new ceramic materials involve several components, but the phase diagram information in many of the systems is lacking. The phase diagrams for quaternary systems (four components) need four dimensions to incorporate the compositional and temperature effects on the phase equilibria. Aza developed a method to solve this problem and has been applying the method to the development and interpretation of these quaternary systems important to the development of ceramics, glass, cements, and refractories (Aza et al., 1974). For example, the following systems have been examined:

1. The ZrO_2-Al_2O_3-SiO_2-TiO_2 system has been studied to understand of the effect on the thermal behavior of the most common impurities in zircon sands (Al_2O_3, SiO_2, TiO_2).
2. The Al_2O_3-SiO_2-CaO-TiO_2 system has been studied to determine the primary phase volume of crystallization of the calcium monoaluminate. This research has allowed the establishment of the most appropriate conditions for obtaining low-iron calcium aluminate cements from white bauxites and lime (both very abundant in Spain).
3. Al_2O_3-SiO_2-TiO_2-Fe_2O_3 and ZrO_2-Al_2O_3-SiO_2-CaO systems have been studied for their refractoriness.

With the recent interest in ZrO_2-based engineering ceramics, Aza has supported the development of these materials at ICV by developing phase equilibria information still lacking for the very complex nine component system: ZrO_2-Al_2O_3-SiO_2-TiO_2-CaO-MgO-Na_2O-Fe_2O_3-FeO. This information has been used in the development of tough engineering ceramics at ICV based on the ZrO_2-mullite ($3Al_2O_3$-SiO_2) system.

Tough Engineering Ceramics

J.S. Moya and coworkers have been studying the effect of processing and impurities on mullite strengthened by ZrO_2. The electron microscopy performed in these studies has been done at the US National Center for Electron Microscopy, Lawrence Berkeley Laboratory, under the direction of Thomas.

The addition of zirconia (ZrO_2) to a ceramic matrix in order to increase toughness and flexural strength has become very common and important. Al_2O_3 and cubic ZrO_2 matrices are more fracture resistant with the addition of partially stabilized tetragonal ZrO_2, which transforms under the influence of the stress field at a crack tip, thus absorbing energy and increasing toughness. The mechanism for toughening mullite by the addition of metastable tetragonal ZrO_2 is, however, not well understood. Moya and Osendi have been studying the relationships among the processing method, microstructure, and mechanical properties of these materials. This work has led to a better understanding of the strengthening mechanisms, methods of processing the materials in order to take advantage of a mechanism for enhanced sintering, processing methods to prevent grain growth during sintering, and methods to eliminate defects from these fine grained high density ceramics.

Reaction sintering at temperatures as low as 1450°C has been successful in producing very dense zirconia-toughened ceramics based on the quarternary systems ZrO_2-Al_2O_3-SiO_2-TiO_2 and ZrO_2-Al_2O_3-SiO_2-MgO. The formation of a transient liquid phase (which disappears in the later stages of sintering) has been shown to be responsible for the high densification rate at this comparatively low temperature.

Considerable research on the mullite strengthened by ZrO_2 will continue at ICV, and it will be focused on

improved methods for powder production and surface activation for enhanced sintering and grain growth restriction.

Materials for Oxygen Sensors

Solid electrolytes are under study (Dr. P. Duran and coworkers). At present most research is on the tetragonal ZrO_2 system for use as oxygen sensors. The research at ICV is focused upon the production of powders by a co-precipitation technique which produces the very fine grain size required for good fracture toughness.

Many different oxides have been added to ZrO_2 to stabilize the tetragonal phase, but to date 2 percent Er_2O_3 has produced the best combination of high electrical conductivity and fracture toughness. Er_2O_3 inhibits grain growth during sintering better than any other oxide investigated (grain diameter <0.3 μm); the mechanisms responsible for this result are under investigation.

CeO_2 with solid solutions of La_2O_3, Nd_2O_3, Sm_2O_3, Gd_2O_3, Er_2O_3, and Y_2O_3 was investigated as an oxygen-sensing material a few years ago. Complex plane impedance analysis was used in order to determine the mechanisms responsible for conductivity as a function of temperature for these systems. These experimental techniques developed with the CeO_2 system are now used in their studies of the ZrO_2 systems.

Piezoelectric Materials

Duran and his coworkers are also studying piezoelectric materials. The effect of powder preparation and production on the sintering behavior and electrical properties of PZT (Pb, Zr, Ti) and PLZT (Pb, La, Zr, Ti) ceramics has been and continues to be a prime area of research. These materials are being developed for use as sensors in, for example, hydrophones. They have found that the final properties (density, dielectric constant, Tg, Curie temperature, Kp, and remnant polarization) are strongly dependent on the microstructure (grain size). The processing steps which have the most important effect on the final microstructure are the methods of coprecipitation, dehydration, and precalcination used to produce the starting powders.

Summary

ICV is concentrating its research efforts on topics that are of current interest. The facilities and staff are increasing steadily. For some of their research, they wisely rely upon collaboration within Europe and the US in order to obtain access to materials and equipment that are impossible to obtain within Spain. Their research in the three fields discussed above is state of the art and the toughened engineering ceramics program is a prime candidate for further collaboration with the US.

Reference

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7/24/85

Mechanics

BASSIN D'ESSAIS DES CARENES: THE PARIS MODEL BASIN

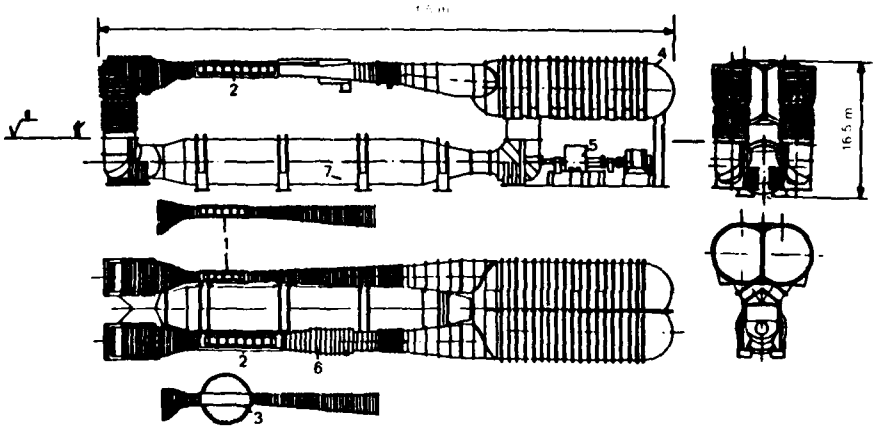
by Patrick Leehey. Dr. Leehey was the Liaison Scientist for Naval Architecture and Applied Mechanics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is Professor of Mechanical and Ocean Engineering at the Massachusetts Institute of Technology.

The Bassin d'Essais des Carenes, the Paris model basin, is one of the world's largest and most diverse ship hydrodynamics test facilities. It has long been noted for innovative experimental research. This tradition has continued through the installation of such extraordinary facilities as an underwater towing carriage and the construction of a new dual test section cavitation tunnel which will include the world's first reverberant test section.

Large Hydrodynamic Tunnel

My visit to the Bassin d'Essais des Carenes was hosted by Dr. Jean Claude Dern, the chief of the Hydrodynamics Section. Our discussions also involved M. Benicourt, Ingenieur en Chef de l'Armement of the Service Technique. He is responsible for all research in acoustics and ship noise sponsored by the French navy. We were also accompanied by Dr. Bovis, the head of the Propeller and Propulsion Research Section.

Our discussions centered on matters related to ship acoustics and most particularly on propeller cavitation. The



1. HSCTS 1.14 x 1.14 x 6 m
2. FSTS 2 x 1.35 x 10 m
3. Acoustic test section
4. Depressed tank
5. Machinery Room
6. Free Surface skimmer
7. Re-scrubber

Figure 1. New water tunnel.

new, dual-test-section, variable-pressure water tunnel is under construction now and is scheduled for completion in 1986. Its principal features are shown in Figure 1. My especial interest in this facility had to do with their design of a rather odd-shaped reverberation test section for acoustic measurements, unfortunately not shown in Figure 1. It is an ungainly looking device having an intentionally irregular shape in order to increase its acoustic mode density. Flow is conducted through a cylindrical steel shell within the reverberant chamber. Propeller and hull models will be installed for test inside this shell. Thus there will be some loss of acoustic energy to the upstream and downstream portions of the tunnel. This is being accounted for by calibration with a known sound source and by scale model tests.

Model tests have been conducted for this test section. Relative to full-scale tunnel, they expect to obtain three to four room modes in a third octave band centered at 300 Hz. This sets one lower limit for possible reverberation measurements. Two tests were conducted on a model of this test section in order to determine the room constant of the facility. In one test a cavitating jet was used in the center of the test section, in a second test the sidewall structure of the facility was excited with random vibration. When the signal from the cavitating jet was shut off, it died much more rapidly than did the corresponding signal for the structural excitation. The cause of this discrepancy is not yet established, but it is almost certainly due to one or both of two things: either the cavitating jet was in fact loaded in a nonlinear way by the reverberation chamber, or the cavitating jet produced a microbubble structure which greatly enhanced the damping of the acoustic field in the reverberation chamber. Ignoring the results of the cavitating jet tests, and relying upon those from structural excitation, they find a typical 1-second reverberation time at 1 kHz. They feel, consequently, that they may be able to do reverberation measurements without a direct field contribution for frequencies down to 600 Hz. This is a very considerable improvement over their present procedure, wherein measurements are made of the cavitation noise of model propellers by a hydrophone located in a recess in the wall of the test section. Here their calibrations show that they are flow noise limited for all frequencies below 2 kHz.

Number 2 Propeller Tunnel

I also observed operations of their Number 2 Propeller Tunnel, a considerably smaller variable-pressure tunnel

than the one currently under construction. This tunnel is equipped with rather extensive water-quality-control system in order to provide control over the microbubble structure in the water. A bleed system from vanes forward of the contraction section provides for controlled microbubble input, and a very large circular settling chamber behind the diffuser provides for very satisfactory air removal. The measurement procedures available include a cavitation susceptibility meter of the venturi type designed by Neyrpic in Grenoble. This device is quite similar to the Oldenziel apparatus in that it determines the downstream pressure at which a rapid rise of cavitation in the throat of the venturi occurs. This pressure is a measure of the cavitation susceptibility of the water. Although the procedure is a bit arbitrary, it has been found useful for control of repeatability of experiments. They have tried to use the system for concentration and bubble size distribution measurements. This, however, is still not a fully satisfactory procedure. They are presently only able to determine the burst rate of cavitation bubbles and/or the long-time-averaged acoustic pressure spectrum related thereto. For their new facility they are considering using a laser scattering device being developed jointly by DISA and Hamburgische Schiffbau-Versuchungsanstalt GmbH at Hamburg.

The new cavitation tunnel is being installed at a facility some 95-km away from Paris. The Number 2 cavitation tunnel will be moved there, and the old Number 1 cavitation tunnel will be permanently dismantled. I expressed my concern to Dr. Dern over the complete removal of cavitation test facilities from the headquarters of the Bassin des Carenes. Such decisions to locate large facilities far from the parent organization have been common in Europe and are becoming increasingly common in the US. My personal opinion is that such compromises are seldom satisfactory. They usually result in the development of separate and competing research groups.

Submerged Towing Carriage

The other extremely interesting facility that I visited was the submerged towing carriage at the bottom of the large Number 1 towing basin. This carriage in fact sits on the bottom of the basin and is driven by an extremely long DC linear motor operated at up to 1500 A. This carriage is used primarily for towed body measurements. It permits towing a body such as a near-surface underwater wing by a towing rig which does not penetrate the water's surface, hence simulating directly a submarine towed system. The carriage itself is essentially a plate extending only 1-m above the bottom surface of the basin. Therefore it makes a minimal disturbance to the near-surface flow. It also does not interfere with the use of wave makers during testing. The system is logical--if unorthodox! A final note: the Paris model basin has also been testing full-scale towed arrays at a 2-km-long towing basin owned by the French air force. This facility had originally been designed for seaplane take-off research.

Conclusion

The work at the Paris model basin seems to be concentrated very heavily on propeller cavitation research and other acoustic problems, on seakeeping and maneuvering, and, of course, on classical ship resistance and self-propulsion tests. These are the main business of any ship hydrodynamics research facility. What makes the Bassin d'Essais des Carenes unique is the innovative and unorthodox manner in which its business is carried out.

8/9/85

Ocean Sciences

MARINE INTERFACIAL AND REMOTE SENSING RESEARCH AT THE UNIVERSITY OF HAMBURG

By Dr. Paul N. Boothe. Dr. Boothe is Research Associate in the Oceanography Department, Texas A&M University, College Station, Texas.

The University of Hamburg (UH) is the center for a small, well-funded, multidisciplinary marine research program studying the air-sea interface (microlayer). The emphasis of this program has been on the effects which surface films or slicks have on capillary and gravity wave damping and microwave remote sensing of the sea surface. This group effectively combines theoretical, physical-chemical modeling with extensive laboratory experiments (using a 19-m wind-wave tunnel) and field experiments to validate and refine their models. Their research has led to an increased understanding of the physical

chemistry of surface active compounds and to the development of an improved wave damping model which more accurately predicts observed wave attentuation by monomolecular surface films. This work--together with several remote sensing field experiments with man-made, simulant monolayer sea slicks--has more precisely defined the structure of the film-water layer and its interaction with both passive and active microwave sensors. Microwave remote sensing of the oceans is expected to increase dramatically over the next decade. The Hamburg group will be important participants in that development.

Background

Special-investigation programs (Sonderforschungsbereich, SFB) are one means by which the German government encourages academic research in selected areas. SFBs typically last for several years and are assigned to researchers at a single university or geographic area.

At the UH in 1971 the German Science Foundation (Deutsche Forschungsgemeinschaft, DFG) started SFB 94, a multidisciplinary program in marine research emphasizing air-sea interface research. Organic surface films research received special emphasis since films can have significant effects on this interface, including wave damping and resultant modifications in electromagnetic emissivity in the visible and microwave bands, scattering of these spectral bands, and gas exchange rates. This program will continue until the end of 1985 with selected extensions probably granted until 1987. The current annual budget for SFB 94 at the UH is DM6 million. SFB 94 represents a significant, well-funded research effort by the DFG. The two prime movers on the project are Dr. H. Huhnerfuss, an organic chemist, and Dr. W. Alpers, a theoretical physicist. Other researchers include Dr. W. Walter, director of the UH Organic Chemistry Institute, and Dr. U.W. Brockmann.

Some perspective concerning the DFG's level of commitment to such select programs can be gained from a description of Huhnerfuss' research team, with whom I spent the most time during my visit. Huhnerfuss holds a research faculty position with no required teaching responsibilities. His salary and laboratory overhead support both come as separate funding from the DFG. The group has free access to UH technicians involved in all phases of instrument fabrication and both analytical organic and inorganic chemistry. The group also has free use of the UH research vessel *Valdivia* (length, 74 m; beam, 11 m; gross tonnage, 1343; maximum speed, 11.5 knots); the German North Sea Research Platform (Forschungsplattform "Nordsee," 54.7°N, 7.2°E); and research aircraft operated by various government agencies. A wind-wave tunnel facility, built in 1974 with SFB 94 funds, is operated by the group and is described in more detail below. The group also receives separate funding annually to support one or two students. In addition, Huhnerfuss' group receives DM350,000 annually from SFB 94 for special investigations. This funding supports two or three full-time technicians and a senior research scientist, Dr. P. Lange, who is in charge of the wind-wave facility. The funding is also used to operate the wind-wave facility and to support participation in various field experiments. This funding has allowed Huhnerfuss to travel widely, developing collaborative relationships in Italy, France, Denmark and the US.

The professional productivity of the Hamburg group has been high. Researchers in the group have authored more than 30 scientific journal papers. The project has produced three PhD degrees (including Dr. Lange), 10 diploma theses (equivalent to a master's degree), and numerous 3-month teacher training projects. Both Huhnerfuss and Alpers have active collaborative research relationships with US scientists, including those at the Office of Naval Research and the Naval Research Laboratory.

Wave Damping Research

The phenomenon of wave damping by surface films is well established. However, the mechanism of this effect is still uncertain. The development of a generally accepted theory lacks an accurate knowledge of the molecular arrangements and rearrangements of both the surface film and water molecules under the dynamic conditions of a wavy water surface.

A major research goal of the UH group has been to provide this knowledge by studying the molecular basis for wave damping by surface films (Hartwig and Herr, 1985). The experimental approach used has been to study both gravity (i.e., frequency <5 Hz) and capillary (i.e., frequency >10 Hz) damping caused by a variety of well-defined, chemically pure artificial monomolecular surface films forming compounds. The hydrophobic alkyl chain ("tail") and hydrophilic ester alcohol ("head group") of these surface active compounds are systematically varied to determine how various molecular rearrangements affect a compound's wave damping ability.

The measurements of wave damping are performed in the UH wind-wave channel located about 20 km from the main campus. The wave channel is 26-m long, 1-m wide and 0.5-m deep, with a hydraulically driven wave flap. The channel has been designed specifically for surface film work. Peristaltic pumps deliver surfactant compounds to the water surface at precisely known rates. All air entering the channel is filtered, and the water surface can quickly be cleaned of films between experimental trials. The channel is equipped with a wave follower to place sensors, such as the Am-241 surface potential detector, at any selected phase of the wave cycle. A wind field of up to 25 m/s can also be imposed on the water surface to study the effect of surface films on wind-wave interactions. Also, an X-band (9.5 GHz, 3 cm) radar is installed in the channel. Wave channel measurements are supplemented by laboratory measurements of surface viscosity, film relaxation, etc., using an automatic Langmuir trough.

These experiments have shown that hydrophobic interactions between alkyl chains and adjacent underlying water play a dominant role in wave damping by inducing "ice-like clathrate structures" (see Huhnerfuss, Lange, and Walter, 1984). Such structures up to 190-μm thick have been inferred in which the deployed monolayer anchors and holds in strong alignment a considerable amount of subsurface water. Maximum wave damping occurs at the C-16 chain length (palmitic acid methyl ester). Most of the fatty acid fraction of natural surface films (i.e., 65 to 80 percent) consists of C-16 and C-18 derivatives. An additional wave energy dissipation term is active in the presence of carboxylic acid esters in the form of an E/Z-isomerization mechanism during wave induced dilatation and compression of the films.

The UH group has recently postulated an expanded theory of gravity wave damping by surface films (see Huhnerfuss, Lange, and Walter, "Part I" and "Part II," in press). This approach is aimed at building a theoretical link between molecular aspects of film-water layer and the wave damping ability of these compounds. This theory is based on wave channel experiments using a surface potential sensor. Surface potential is a surface charge and oriented dipole-related measurement which is very sensitive to surface film concentration gradients. This study has confirmed that gravity water waves induce surface concentration and surface tension gradients in monomolecular films. These gradients induced by the compression and dilatation of the wave action induce significant horizontal compensating water movements. These horizontal, longitudinal, oscillating water movements--termed "Marangoni waves"--lead to intensive energy dissipation via viscous friction between surface and subsurface water layers. Wave damping is the result of this energy dissipation process. By using visco-elastic parameters of the film-water layer measured under dynamic conditions (which are lower than similar values obtained by classical Langmuir-trough measurements), the proposed theory gives excellent agreement between predicted and observed wave damping by several surfactant compounds.

Remote Sensing Research

Microwave and infrared remote sensors are all "skin layer" detectors, which do not penetrate below the sea surface. Natural organic compounds at the sea-surface interface do influence the dynamic range of microwave and infrared remote sensing instruments. This influence is sometimes found in signal enhancement or retardation and in modification of the "depth of look" and "noise signature" in the sea-surface zone. The UH group has been very active in studying the interaction between surface films and remote sensing imagery. Alpers, who is involved in much of the ongoing remote sensing research in West Germany, is the prime mover for this work in the UH group.

The Hamburg group has participated in several large-scale remote sensing experiments utilizing artificial slicks usually dispersed from aircraft as frozen chunks of pure surface-active compounds. These studies include JONSWAP (Joint North Sea Wave Project) in 1975, the Office of Naval Research-sponsored MARSEN (Marine Remote Sensing experiment) in the North Sea in 1979, and ARCHIMEDES I off the Dutch coast in 1983. The group also was to participate ARCHIMEDES II during October 1985 in the North Sea. This project is aimed at refining remote sensing techniques for the detection of marine oil pollution (for more details see ONR, London, *Military Applications Summary Bulletin* 73-85 [12 July 1985]). This field work has shown how the chemical composition of surfactant compounds can affect the backscatter signature in various radar bands (Huhnerfuss, Alpers et al., 1983). Also during the MARSEN experiment, a large decrease in the passive microwave brightness temperature at 1.43 GHz (L-Band) was observed. This represents a new anomalous-dispersion-frequency regime for water which is caused by "ice-like clathrate structures" induced at

the sea surface by surfactant compounds (Huhnerfuss and Alpers, 1983).

Outlook

There is a clear consensus that over the next decade increasing emphasis will be given to microwave remote sensing of the oceans, using passive and active devices. The US Navy's interest in this trend is clearly shown by the Office of Naval Research-sponsored workshop held in October 1984 (Hartwig and Herr, 1985). Three of the researchers from the UH group attended that workshop. The members of this group will certainly be major participants in future programs related to marine remote sensing.

Huhnerfuss' group will complete its work on SFB 94 in 1987. In 1986 the laboratory will begin working on a new SFB dealing with pollution of the North Sea. Work will continue on surface film modeling and experimentation (i.e., wind-wave channel, field projects), with emphasis given to how pollutants interact with marine surface films. A goal of this research will be to develop ways of using remote sensing techniques to discriminate pollutants and other organic compounds at the sea surface. Plans are under way to establish a multidisciplinary marine science center at the UH. If approved, the center would create a single focus for marine research in the area, including the potential for private industrial funding. Some increase in the professional staff and facilities would also be involved.

Alpers has recently moved to the University of Bremen, where he will be director of a new remote sensing center and a member of the Polar Research Institute. His group will include five PhD researchers as well as visiting investigators. A new area of emphasis for this group will be in the remote sensing of sea ice as part of a new SFB dealing with interactions between the atmosphere, sea, and ice in the northern polar region. Alpers' group is also involved with development of sensors for the European Space Agency's Earth Resources Satellite (ERS-1) and an experimental airborne synthetic aperture radar (SAR). Alpers will maintain his collaboration with UH researchers concerning the remote sensing of sea slicks. He will also continue his theoretical work on SAR imaging.

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8/6/85

Physics

APPLIED OPTOELECTRONICS AT OBERPFAFFENHOFEN

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1987.

Modular optoelectronic multispectral scanners, interactive digital image analyzers, high-powered models for infrared signature studies, a mini-lidar, an unconventional laser-Doppler-anemometer, and advanced imaging systems based on charge-coupled-devices are currently the focal points of excitement for West Germany's Institute for Optoelectronics. This institute, which has 65 academic scientists and about 150 technical support workers, operates within the organizational framework of the Research

Department for Telecommunications Technology and Remote Sensing (250 scientists plus 600 support personnel), one of the five thematic directorates of the Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR), that is to say, the government-financed German Aerospace Research Establishment.

The institute, together with one for Telecommunications, one for High Frequency Technology, and one for Atmospheric Physics, is located on the charming rural plains at Oberpfaffenhoffen, about 25-km west of Munich.

Background and Overview

DFVLR, with a total staff of 3200 that includes 1700 scientists, is the largest West German research complex in the field of engineering sciences. It has five research centers, located all over the country, and six additional branch plants. (An article describing the organizational structure of DFVLR appeared in *ESN* 39-3:115 [1985].) The statutory objectives of DFVLR encompass research in aerospace and space sciences and technology, construction and operation of large-scale test facilities, assistance to federal and state authorities, participation in national and international large-scale projects, and advanced-level training of young scientists and engineers. Apart from traditional activities in aerospace research (navigation, aircraft improvement, air traffic control, etc.), focal areas are environmental research, planetary exploration, energetics (including propulsion technology), and communications.

The specific object of my visit to DFVLR in July was to become acquainted with the Institute of Optoelectronics. The primary task of this institute, directed ably and sensitively by Professor Dr. F. Lanzl and his assistant, Professor Dr. J. Landauer, is remote sensing via optical methods. The term "remote sensing" is taken in its broadest sense and covers a vast area of civilian and military applications, including imaging of land and sea by airborne scanners and camera systems, development of new sensor systems, development of advanced charge-coupled-device (CCD) cameras for use in satellites to obtain stereo images of the surface of the earth, investigation of infrared (IR) signatures of objects and their storage in a data bank, construction of a CO_2 laser Doppler sensor system, and many other enterprises.

The institute has five divisions:

1. Optical Remote Sensing. This division's work is the focus of the institute's mission. Visible, near- and middle-IR sensing, and thermal imaging are all covered. One major achievement was the development of a high precision metric camera, used on the first Spacelab flight; an improved version will be flown in 1986. Equally significant is the work concerned with multispectral scanners used for long-distance recognition of aircraft. High resolution (up to 128 channels in IR and mid-IR) CCD technology has been developed in the division and used both for forest damage research and oceanography of coastal areas.

2. Infrared Technology. The mandate of this division is to develop methods for recognizing military objects on the basis of the heat radiation patterns. Both exhaust gases and ground objects are considered as sources to be detected and analyzed. Most activities focus on the 3- to 5-μm and the 8- to 14-μm radiation ranges.

3. Digital Image Analysis. This division works very closely with the infrared researchers. Original aims of the scientists in this division were the development and implementation of image-processing algorithms and their use primarily for terrestrial remote sensing.

4. Planetary Research. Computer-aided image processing and CCD technology are the scientific concerns in this division, which is busily occupied with the analysis of remote data from planetary objects. Current activities include the Galileo project: with newly developed CCD cameras, the scientists will look next year at an asteroid and then at the Jupiter area. A subsequently planned German-US joint project will be the "Mars observer." The division is also engaged in CCD-sensor and linear multidiode sensor research (quality assessment and improvement) related to the 1986 European (German dominated) Giotto project, which will explore the tail and head of Halley's comet.

5. Laser Technology. Whereas the other divisions focus on passive sensing techniques, this, the latest among the five, is concerned with the use of various laser-beam probing technologies. Both incoherent (lidar) and coherent (heterodyne reception) laser remote sensing figure among activities. Minilidars were constructed and used to study aerosol backscattering; sideview-distance lidars to explore backscatter and absorption caused by fog droplets; and a fluorescence lidar to explore environmental problems through observing induced fluorescence of suspended particles. Heterodyne laser radars were used as Doppler anemometers, as distance and velocity probes of moving targets, and

Table 1

Overview of Research Activities

Division	Topical Focus	Applications
Optical remote sensing	Visible and IR sensors. Methodology.	Thematic cartography of the sea, coastal areas, and terrestrial vegetation. Topographic cartography. Spacelab applications. Aircraft recognition.
Infrared technology	Thermal IR sensors Infrared signatures. Overall and subsystem models.	Reconnaissance. Thermal cartography.
Digital image analysis	Methodology and systems for image processing. Special adaptive models. Evaluation.	Thematic cartography of land, sea, and atmospheric signatures. Three-dimensional information extraction.
Planetary research	CDD sensor technology. Image processing, evaluation, and interpretation. Models of planetary development.	Properties of solid planetary surfaces. Topographic and geologic cartography.
Laser technology	Lidars. Heterodyne receivers.	Atmospheric parameters, including turbulence. Surface properties of water and land areas.

as airborne or spaceborne prospectors (using massive reflection from the surface) for finding mineral deposits or studying soil properties.

A summary of research activities from another viewpoint than was followed in the preceding description is presented in Table 1.

Selected Research Areas

In the following I will describe a few specific activities at the institute that caught my fancy.

Modular Optoelectronic Multispectral Scanner (MOMS). This project, in part subcontracted to Messerschmitt-Bölkow-Blohm in Ottobrun began over 6 years ago, and led to a system which has two distinguishing features. First, it has two independent modules, one for the 575- to 625-nm visible range and one for the 825- to 975-nm near-IR range, each containing an objective, a filter, a linear sensor, and complete preamplifier electronics. The advantage of this arrangement is that it makes it possible to combine a variety of different narrowband or broadband spectral regions. The second innovative feature of MOMS was the application of CCD line sensors, which made the use of mirrors unnecessary, and thus eliminated geometrical distortion and position wobble in the time span of a line-scanning operation. (CCD linear sensors allow for central-perspective imaging in a line.) The system used the "push-broom" scanning principle--i.e., electronic scanning across the flight path--and the large number of discrete photosensitive elements correspond directly to subtrack ground pixels.

The latest test of MOMS took place in 1984, during the 11th US space shuttle flight. Some interesting specifications of MOMS are: (1) total field of view: 26.2 degrees; (2) field of view per pixel (i.e., instantaneous view): 67.5 μrad; (3) number of pixels per line: 6912; and (4) ground pixel size for a 300-km-high orbit: 20 m.

In the near future two additional mid-IR channels will be added, in the 1.5- to 1.7-μm and the 2.1- to 2.3-μm range, and stereo capabilities will be developed. New detector materials (Si, PbTe) will also be used.

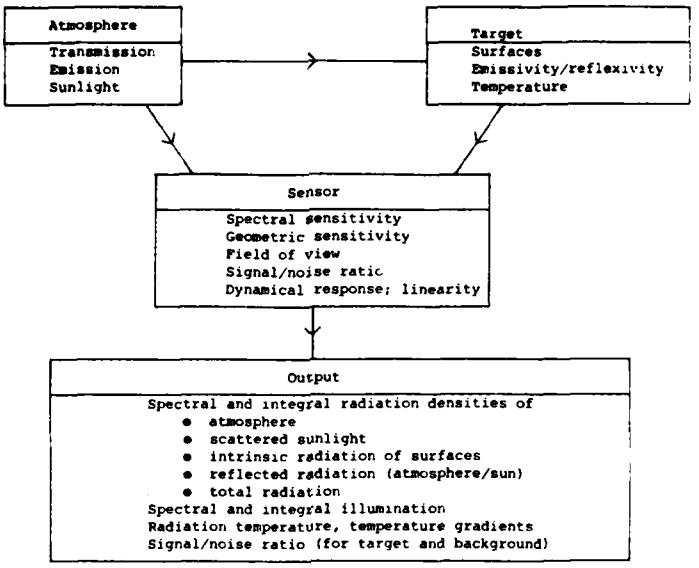

Figure 1. Block diagram of SENSAT.

Mobile Infrared Data Acquisition System (MOBIS). Research on infrared signature studies deals with the dependence of radiometric quantifiers--such as spectral or integral radiation density, and pointwise or area-wise radiation intensity--as a function of specific object or environmental parameters. These studies play a very important role in the institute's past and current activities. The new MOBIS project (executed in the frame of a North Atlantic Treaty Organization [NATO] cooperation) studies thermal images in the 3- to 5-μm and the 8- to 14-μm range. It uses two commercial AGA cameras with a one-element, liquid nitrogen cooled detector. The special feature is the combination of real-time data calibration, quick-look capability, data-quality check, in-built image analysis, and on-line decision making. The procedures are performed by a computer-assisted Fourier spectrometer unit (yielding high-resolution emission spectra) which is used in combination with thermal imaging, forward-looking IR sensors, and line scanners--all controlled and correlated by a 1-Mb Perkin-Elmer 3220 microprocessor. The data are immediately recorded and are thus available also to external investigators. One advanced feature of the system is complete digitalization. Including the recording on a disk, the data flow rate is 640 kb/s. No quality loss (versus the older analog processing) was found.

Sensor-Atmosphere-Target Simulation Model (SENSAT). Figure 1 is the block diagram of this comprehensive computer program that can simulate many typical scenarios in remote sensing and reconnaissance. The submodel "Atmosphere" uses the US-made LOWTRAN6 simulation. The submodel "Target" permits simulation of up to three different object or background surfaces simultaneously in the viewing field of a sensor. (The surfaces are treated as unstructured.) The rest of the model is self-evident from the figure.

The results of simulations done with SENSAT proved most valuable in mission analysis of sensors mounted on different platforms, such as the study of variation of atmospheric and object parameters or estimation of the maximal admissible flying height. SENSAT is also useful for analyzing variations of sensor parameters, and for chosing spectral filters. Obviously, the significance of SENSAT lies in the fact that it is a powerful tool for critical assessment of parameters and sensitivities, which are indeed best acquired before the deployment of an expensive system is attempted.

At this point I want to mention that the institute also has completed the design of a much more complicated simulation program, the so-called Infrared Radiation Model Air Targets (IRMA) model, which will be incorporated as a major component into the vast NATO Infrared Air Target Model (NIRATAM). The purpose of this project is to allow study of the IR signatures of airplanes and rockets. In particular, IRMA calculates the flow field of gas jets and from it the temperature distributions in the stream jet. Molecular band theory is

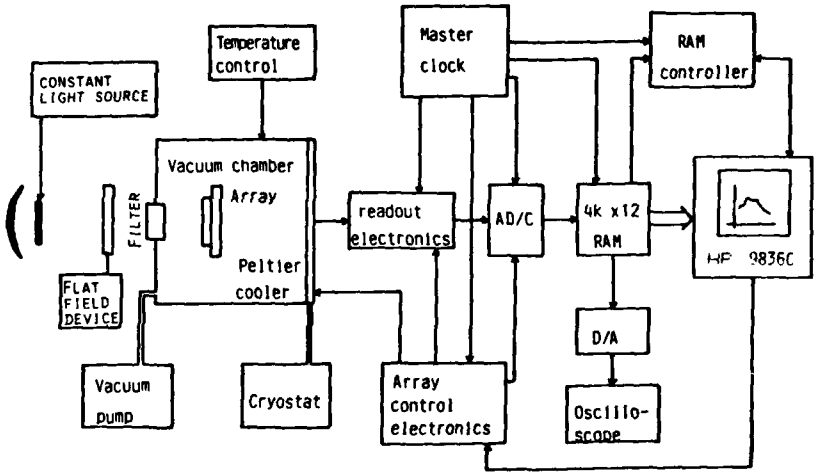

Figure 2. Block scheme of the CCD test facility.

used to calculate the spectral emission of the hot gas jet. The radiation from the propulsion vent is also determined, using geometric and thermal parameters. IRMA is now in the test and verification phase of development.

CCD Sensor Technology. Plans for widespread use of CCD cameras in space research sparked off an extensive research and development program at the institute. The general aim of this activity is to study in depth the behavior of CCD devices and arrays of sensors. Using specifically developed steering and readout electronics, a set of parameters and their dependence on external factors (changes in voltage, pulse form, and temperature) are being investigated. The relevant parameters fall into four groups: semiconductor properties (spectral response, quantum efficiency, linearity, dark current); geometric effects (pixel nonuniformity, optical transfer function); factors related to the double-readout register (odd-even effect, charge transfer efficiency); and parameters of the readout amplifier (readout noise, frequency range). The researchers pointed out to me that the most important parameters of the entire CCD sensor system are its dynamical range and its modulation transfer function. (These result from combinations of the above-listed specific parameters.) The current research aims both at studying the effects of the variation of external parameters on the functional parameters, and at optimizing a selected substantial subset of functional parameters.

The measurements are done with a home-built elaborate test facility (see Figure 2). In the evacuated test chamber the arrays being studied can be kept at temperatures between -30°C and +30°C. The resolution of the electronics used for steering and readout of the CCDs is 12 bit. The data are processed and evaluated by a small computer that is coupled to the testing electronics and that uses sophisticated software packages. The optical part of the test facility consists of a highly stable commercial halogen light source, a diffuser disk, and selectable filters. In the future, the electronic tests will be supplemented by electron microscopic measurements which will permit the researchers to study simultaneously the structural properties and the charge transport processes of the CCDs. A further modification of the test facility will allow the study of not only linear, but also of two-dimensional CCD arrays.

The test facility was used both for basic studies as well as for selecting "space-qualified" components for missions, including Galileo and Giotto. The latter will be the first extraterrestrial mission using CCD sensors. Figure 3 shows the spectral responsivity of one of the selected sensors.

Lasers as Sensors. One advantage of laser sensor systems over passive sensors is, of course, that laser methods do not depend on the self-emittance of the objects. Another advantage is that it is possible to operate a pulsed laser as an optical analog of the radar (lidar). In these devices the sender is combined with a detector, and the received signal is time-sequence analyzed. Lidars can be used both to study land or water surfaces, as well as the density distribution of aerosols (or in

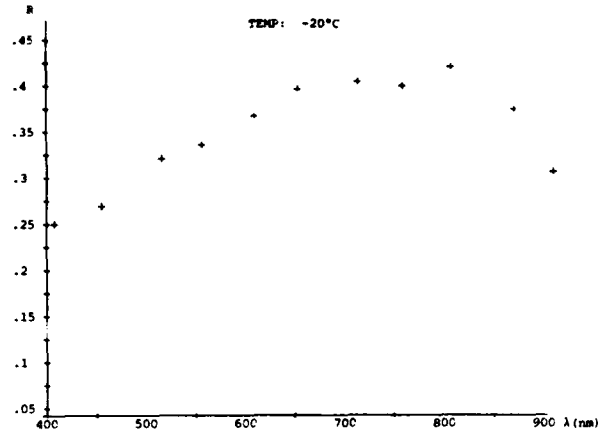

Figure 3. Spectral responsivity of the CCD array selected for Giotto.

favorable cases, even of gas molecules) in the air. Simultaneous distance measurement is also possible.

The researchers at the institute developed a compact, mobile, land-based mini-lidar with a pulse length that allows a resolution better than a meter in routine applications. The radiation source was a compact Nd:Yag laser (operating at 1.06 μm). On-line data processing was incorporated which, by ascertaining the strength of the returned signal, emitted a real-time determination of the concentration of particles suspended in the atmosphere. Apart from industrial pollution aerosol-mass determinations, the mini-lidar was successfully used in experiments on the North Sea that studied the propagation parameters of artificially produced aerosols over the sea surface. The aerosols were released from ship sources, and their spatial and temporal propagation was followed by a shipborne mini-lidar. The "aerosol flag" was followed downwind, and the measurements were made in the direction perpendicular to the wind. The measurements showed that the propagation parameters are correctly predicted by aerodynamical theory if Gaussian profiles are assumed. It was found that sea currents significantly influence the propagation. Further, the propagation parameters depend strongly on the hygroscopic behavior of the particles.

In another research project, the mini-lidar was modified to serve as a fluorescence lidar. To this end, a frequency doubler was inserted, and the receiver was equipped with fluorescence-responsive detection capability. The adapted data processing again gave an on-line readout. The weight-optimized lidar was flown on an airplane. Oceanographic work focused on measurement of plankton and yellow-material concentrations, and later on the remote sensing and evaluation of oil pollution.

In a number of remote sensing problems (including wind velocity and distribution measurements, or airplane-made turbulence observations, or simultaneous distance and velocity measurement of moving targets), the direct-detection method used by the incoherent receiver of a lidar is not suitable for obtaining high-quality results. In addition, some applications require the use of longer wavelength CO_2 lasers (operating at 10 μm), which has two advantages: atmospheric turbulence has less effect, and the optomechanical construction is simpler. However, at this wavelength the detectors have a sensitivity reduced by a factor of 10 (as compared to systems operating with visible light). In order to register these weak signals with an acceptable signal-to-noise ratio, it is necessary to use heterodyne (frequency mixing, "coherent") receivers. Simultaneously, with such receivers it is possible to determine the Doppler shift of the signals received from moving objects, enabling the high precision realization of tasks as outlined at the beginning of this paragraph.

In earlier work, the institute developed a Doppler anemometer with a continuous-wave CO_2 laser source, a telescope, and a simple homodyne receiver. Homodyne operation means that no extra local oscillator is used, since the returning frequency-shifted signals are combined with the unshifted radiation of the emitter. (Later inclusion of a locked auxiliary CO_2 waveguide laser oscillator allowed also for measuring the sign of the wind velocity--this arrangement was a compromise between the homodyne and heterodyne operation modes.) Determining the Doppler shift caused by ever-present aerosol particles in the air, wind velocities could be measured with a precision of 1 m/s, up to distances of about 1 km, and in all weather conditions. However, these experiments also revealed that further improvement of range and of distance resolution necessitates the development of a complete, pulsed, heterodyne system. Figure 4 is a schematic representation of the DFVLR pulsed heterodyne laser system. The transmitter produces pulses with 400-ns duration. The returning pulses enter a mixer where they are combined with the continuous wave output of a local oscillator. All performance aspects of this system have been carefully analyzed and optimized. For example, Figure 5 illustrates the heterodyne

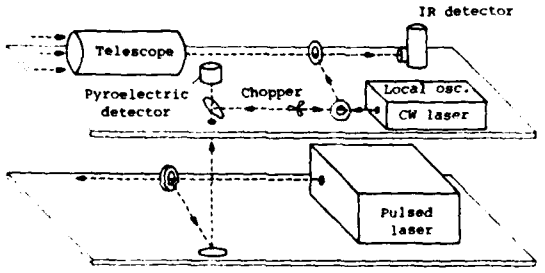

Figure 4. Block diagram of pulsed heterodyne system.

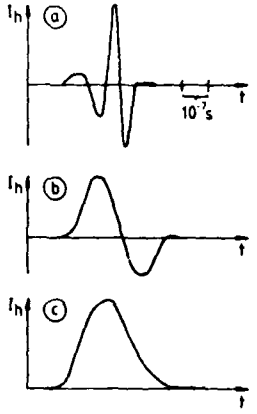

Figure 5. Heterodyne signals.

signals from a fixed target when the intermediate frequency was 7.7, 2.7, and 2.0 MHz, respectively. It shows clearly that when the local oscillator frequency is chosen so that the intermediate frequency is less than the laser pulse frequency (in this case, the 400-ns pulse length corresponded to a 2.5 MHz frequency), then the received pulse is not distorted at all.

Current plans include the development of a compact mini-laser Doppler anemometer.

Outlook

Encouraged by their successes in diverse areas, all tied together by the same philosophy of developing optical sensing and detection systems, the scientists at the Institute for Optoelectronics are confidently sketching their plans for the next decade. Projects for remote sensing from space and from airborne platforms include the construction of a fully automated metric camera, a high-power CCD multispectral scanner, visible and IR optomechanical scanners, IR two-dimensional focal plane CCD arrays, imaging spectrometers, space-based laser systems, active/passive and optical/microwave sensor combinations, to mention only the most important ones. In addition, cooperation with other institutes in the Ottobrun-located research department of DFVLR will widen the scope of sensor development into nonoptical areas as well. The broad-based talent pool of the institute guarantees that it may very will become one of the world's foremost research centers in applied, mission-oriented optoelectronics.

8/9/85

A SUCCESSFUL INTERNATIONAL LASER GATHERING IN MUNICH

by Paul Roman.

The 25th birthday of the laser has been celebrated by several meetings all over the world. One of the notable gatherings, less well known to the US scientific community, took place from 1 through 5 July in Munich, West Germany: it was the Seventh International Congress and International Trade Fair in a biennial sequence of meetings in existence since 1973, and, appropriately, its German title was "Laser 85: Optoelektronik."

As one of the organizers and speakers pointed out, today we know of about 140 "laser-gases" that can lase at 6500 spectral lines, 300 materials suitable for solid state lasers, 100 laser dyes, and several dozens of different types of semiconductor lasers. Some 5000 new papers are written each year about lasers and applications, and the total laser literature is estimated to consist of about 100,000 items. It has been estimated that the world laser market (including peripherals and R&D work) amounted in 1985 to about $9 billion, and has an annual growth rate of 30 percent.

No wonder, then, that despite the frequency of various laser conferences, the Munich congress attracted well over 2000 participants. The majority were Europeans, with Germans in the lead, but practically every industrialized country in the world was well represented, including also a surprisingly strong delegation from the People's Republic of China and from Hungary. The accompanying trade fair attracted 200 exhibitors from 13 countries (30 percent more than in

1983). Interestingly, France, the United Kingdom, and the US had "national exhibitions."

ONR, London, conference report C-7-85 has been prepared to present a technical review; in this article I only attempt to give a general flavor of the meeting, so that colleagues who do not receive ONRL reports automatically may contact me, if they wish, for details or copies of the abstracts. (To order conference report C-7-85, fill out the return mailer inside the back cover of this issue.)

In actual fact, the congress consisted of two distinct parts: one comprising laser physics, technology, and general optoelectronics applications, and the other focusing on medical laser technology and biological applications. The second activity was supplemented by the simultaneously occurring 2nd International Nd:Yag Laser Conference. In the following discussion I will talk only about the first component of the Munich meeting and just mention here that in the medical-related area there was a total of nearly 100 presentations.

The physics-technology component of the congress featured 16 plenary sessions where the state of the art of different areas was given an overview in 40- to 60-minute-long surveys. The topics ranged from developments in solid state lasers and laser chemistry through high power industrial laser systems, commercial excimer lasers, environmental laser applications, optoelectronic sensor systems, to perspectives on optoelectronic components, automatic image analysis, and optical methods of information storage. The body of the congress, however, consisted of 145 research papers, each presented in a 15-minute talk (see below). There were also two symposia ("The Role of Lasers in World Economy" and "Laser Applications in Chemistry") and a "Retrospective and Case Study on the Development of the Laser" (presented by T. Maiman, who in 1960 first succeeded in building a laser). Finally, there were five tutorial talks given on a very simple but efficient level. Mercifully, there were no poster sessions.

I was favorably impressed by the conciseness and clarity of presentation that characterized most of the research paper talks which I could attend. (Needless to say, there were several parallel sessions in all areas.) The excellent organization of the meeting and the self-discipline of the speakers allowed for sufficient time for discussions; but I had the impression that most questions focused on minor technical (as opposed to basic-science) details.

The research papers were well grouped into specific sessions. Not surprisingly, several sessions focused on laser applications in material processing. CO_2 lasers received the most attention, followed closely by Nd:Yag lasers and a few presentations on ultraviolet (excimer) laser applications.

Two full afternoons were dedicated to new developments in laser systems: for me, these were the most exciting contributions. These talks were grouped into subsessions as follows:

1. Gas lasers, excimers, and novel CO_2 lasers,
2. New developments in tunable solid-state and color-center lasers,
3. Diode, infrared, submillimeter, and He-Ne lasers,
4. Short pulse laser systems,
5. Applications of VUV and IR lasers in various basic physics areas.

Two long sessions were dedicated to laser and optoelectronic measurement techniques (metrology), two sessions to the use of lasers in environmental studies, one session to optoelectronic signal transmission.

Finally, a most challenging afternoon session concentrated on the use of lasers and optoelectronics in space technology.

Since it may be indicative of trends, I would like to conclude this brief review by summarizing the areas into which the exhibitions were grouped by the organizers. The major focal points were: (1) lasers and complete laser systems; (2) optical and mechanical components and accessories; (3) measuring instrumentation, sensing, and control equipment; (4) light and other radiation detectors; (5) optical signal transmission, modulating and deflecting systems, light-emitting components, and displays; (6) holographic and photographic equipment; (7) protection equipment.

In summary: this was a successful, pleasant, stimulating congress where the interaction of scientists, engineers, and technologists was consciously nurtured and where a very good picture of new trends could be gained.

8/5/85

DEFENSE- AND SPACE-RELATED LASER AND OPTOELECTRONICS RESEARCH AT MBB

by Paul Roman.

Going back to a long-standing aerospace R&D tradition, Messerschmitt-Bölkow-Blohm GmbH (MBB) is today one of

the leading defense-related private enterprises in West Germany. Apart from government-sponsored work, MBB is also active in securing a firm hold in selected areas of the civilian and commercial market, such as medical and industrial lasers. Its central basic-research laboratory, under the strong direction of the young and imaginative Dr. W. Kroy, is at Ottobrun, a southeastern suburb of Munich. There are over 200 R&D projects in progress. The electro-optic group, which I visited in July, employs 40 physicists and other scientists/engineers, as well as many technical support personnel. In this article I will give a cursory overview of some current research projects in my field, ranging from laser radars and underwater laser detectors through laser warning sensors to imaging and sensor technology. Because of proprietary and security reasons, unfortunately I could not obtain as detailed information as is usually the basis of *ESN* articles. But I believe that the listing of topics and approaches may arouse the interest of some readers, who then can contact MBB directly.

The electro-optic research is focused on four areas, and I review activities under the appropriate headings below.

Optics and Laser Technology

Laser Radar for the European Space Agency. Essentially this system is a self-sustained laser-ranging and target-tracking facility, originally developed for operations in space, such as satellite docking and reconnaissance; but it can be profitably used in other applications too, including robotics. The modular setup consists of a pulsed semiconductor diode laser range finder, a microprocessor control and data-processing system, and a beam deflector unit. The laser operates at 900 nm; each pulse has 10-W power, and the repetition rate is 7-kHz. The receiver part of the range finder uses a silicon avalanche sensor and is equipped with a 5-cm optics. Currently the system operates between ranges of 2 m to 20 km (with a resolution of 1 mm to 3 km). The system has been functionally tested. Work to extend the range to 200 km is in progress.

Underwater Laser Detection of Submarines. This is a joint German-Swedish project, with the task of locating submerged submarines in shallow but possibly turbid coastal waters. The system is mounted either on a helicopter or on an underwater drone. A frequency-doubled Nd:Yag laser (or, in later models, a diode laser) is the source, and heterodyne reception is used. Success in obtaining usable reflection curves (such as illustrated in Figure 1) depends crucially on clever filtering and elaborate optical processing. In clear water, the underwater detection range can be as big as 150 m, and in turbid water it is 20 m.

Tactical Battlefield High-Energy Lasers. Work on a CO_2 gas dynamic laser (operating at 10-μm wavelength) began 10 years ago, and recently the project passed on from the basic research to the development phase. The basic research effort was accomplished with the use of a pulsed combustor which served to improve efficiency. A membrane nozzle was developed, with an area ratio of well over 100. The test lasers have operated with more than 10-kW power in continuous wave mode, for several-second-long bursts. At least 3-percent efficiency was achieved. Not much is known about the latest versions, except that liquid benzene fuel with nitrous oxide as the oxidizer is used, and that new pumping mechanisms employ also water vapor or hydrogen fluoride. Naturally, the development of the laser system required also the solution of difficult optical engineering problems, such as the construction of a lightweight but stiff mirror with deforming optics, and the development of large focusing telescopes (using carbon fiber materials).

The compact system would be mounted on a tracked armored vehicle and is meant to be used as an antimissile or antiaircraft weapon with a range exceeding 10 km, and twice that range when used in an antisensor mission. In connection with the antisensor application, I should mention that MBB has developed thermal sensors that can detect enemy heat-imagers and other sensors simply by using the fact that these objects show up as cold spots in a thermal image of an approaching vehicle or other propelled object. An alternative, active method developed by MBB scientists to detect hostile infrared sensors on the battlefield is to use a medium-energy laser as

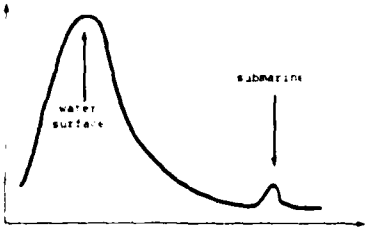

Figure 1. "Inverse shadow" from the sea with submerged object.

a "glare laser" (detecting the reflection of the glare). The same laser may then initiate the engagement of the enemy's sensor by a blinding laser.

Laser Warning Receivers. The purpose of such devices is to detect (from aircraft, tanks, or ships) pulsed enemy laser range finders or laser target acquisition systems. MBB warning systems are based currently on Si and Ge detectors for the 0.6- to 1.9-μm range, and work is in progress with HgCdTe sensors which (depending on composition) could detect radiation up to 20-μm wavelength. The researchers attempt to build cheap, efficient, single-chip detector systems.

The direction of the enemy laser will be ascertained by a clever arrangement shown in Figure 2. The "start detector" has a 180-degree field of view and produces a sharp pulse when it "sees" an enemy laser flash. The "stop detector" is connected to a fanned-out set of directed imaging lenses by optical fibers of slightly differing lengths. The direction from which the pulse came is then calculated from the time lag between the start-detector pulse and the "center of mass" of the pulses produced in the stop-detector from the few signals coming in from adjacent lenses that "face" the enemy laser. The trick, of course, is to have excellent time discrimination.

Optoelectronic Imaging and Cameras

I have very little to say about these MBB efforts. It appears that the major concern is to employ cheap sensors arranged in extemely long (8000 element) arrays, to be used in "push-broom" scan mode systems. Currently the work proceeds with Si sensor elements; plans have been developed to use cooled PtSi sensors. This research will be done with French cooperation. One scientist complained that efforts to do the research as a joint US-German project failed because, they say, the "US tries to keep Europeans away from this novel field of development." Other "optonic device" plans concern three-dimensional imaging.

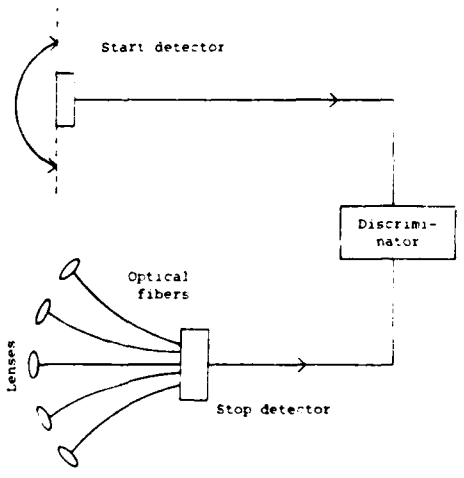

Figure 2. Scheme of direction-sensitive laser warning system.

Sensor Technology, Solid State Physics, Materials Science

The thrust of the work in this area is toward combining, on one chip, optical sensors and microelectronics so as to achieve a complete integration of the sensing function and associated information processing ("intelligence"). It is hoped that, using cheap chips, ultimately a classic digital video signal will be produced by the integrated sensor systems.

Another project is the development of a micro-optic infrared correlator and of moving apertures, based on mixed phase neumatic liquid crystal materials.

Finally, good initial results have been obtained with amorphous silicon coatings for solar energy conversion. The coating can be applied to any surface, of almost any size.

Image Processing

I was told that breakthrough results have been recently achieved in digital optical image processing. Particularly good progress was obtained in Fourier filtering. The long-range aim is the combination and full integration of optical and digital circuits.

Outlook

In addition to continued growth in the areas sketched above, MBB scientists are now initiating new focal points of research. One is the development of magnetic sensors. The other is "bionic studies," a term which is meant to indicate efforts that, imitating living creatures, attempt the use of optical flow data (combined with artificial intelligence) for gyroless navigation and missile control.

Even though I could not learn details of these new research enterprises, I am sure that the optoelectronic research group of MBB is a highly competent, successful, and aggressive community of scientists. There should be many avenues opened up for sharing better in their work.

8/14/85

News and Notes

FIBER OPTIC SENSORS: RECENT WORK IN GERMANY, SWEDEN, AND ITALY

Traditional fiber research and development has to date been oriented toward military applications. However, some multimode sensor projects in West Germany, Sweden, and Italy are generally claimed to be more "practical" because they can use fiber, connectors, and inexpensive light sources from the communications industry. They offer the promise of inexpensive and, in some cases, disposable sensors for pressure, temperature, pH, chemicals, and magnetic fields.

Multimode sensor work emphasizes industrial and medical applications; the general goal is to build systems that use:

- Light emitting diode (LED), not laser, sources
- Multimode fiber of arbitrary length
- Commercially available connectors
- Spectral modulation techniques or the equivalent for drift minimization.

LEDs and multimode fiber are used to reduce sensor cost as well as relax mechanical tolerance problems. In contrast to laser/monomode systems, spectral modulation techniques are used to provide a reliable reference signal which (to first order) eliminates readout drift.

Technische Universität

At the Technische Universität, Hamburg-Harburg, West Germany, fiber optics research is directed by Prof. Dr. Reinhard Ulrich, who is internationally recognized in the field. Despite their recent organization, this group has produced significant research results in fiber optic sensors. Two of the group's multimode fiber sensor concepts are particularly noteworthy.

One concept, described by Bosselman (1984), involves measurement of mechanical position to a reproducibility of 10^{-5} mm out of a 20-mm range. The second sensor being developed at Harburg has broad application to sensing mechanical thermal or magnetic phenomena that can be related to a polarization rotation. This technique, first described by Dabkiewicz (1985), is especially interesting because of its unique spectral encoding technique.

ASEA Innovation

ASEA Innovation, Vasteras, Sweden, serves worldwide markets in electric power and process technology; it is frequently called "the GE of Sweden." Beginning with the need to monitor power-distribution-product temperature, a fiber optic sensing project was started in 1977. This group is currently managed by Christer Ovren and has grown to 30 members. Since 1983 ASEA has developed fiber sensor products for markets outside the company; they are sold in the US through American HV Test Systems Inc., Accident, Maryland.

The ASEA optical sensing group is one of the world leaders in development of industrial fiber optic sensor instruments. Their early development of techniques for normalizing LED output variations is the key to their industry lead.

Standard Elektrik Lorenz AG

A fiber optic gyro project (until recently in the research department) is now being pursued by a gyro group of the avionics development portion of Standard Electrik Lorenz AG (SEL), located in Zuffenhausen, West Germany. Technology related to gyro development, including integrated optic phase shifter fabrication, has been moved to Zuffenhausen. The gyro group is led by Dr. Wilfred Auch.

Traditionally, fiber gyro design has been directed toward an all-fiber (as at Stanford University) or integrated optics (e.g., Thompson-CSF) approach. SEL uses a hybrid design with both fiber couplers and integrated optics components.

Fiber optic technology is shared with a fiber hydrophone project led by Dr. Walter Steudle. Technology support by the research department is provided by Dr. Fred Mohr's group in the area of light source stabilization and fiber splicing.

Fraunhofer Institute

Fraunhofer Institute for Physical Measurement Technology, Freiburg, West Germany, has a goal of transferring concepts to industry and other users. This generally means development to the stage of prototype demonstration. Dr. R. Kist leads a fiber optic sensor group at Freiburg that has developed a number of sensors. Previously demonstrated fiber optic devices include a liquid refractive index sensor. It is now being commercially produced for measurement of the sugar content in food.

The current emphasis in Freiburg is on Fabry-Perot sensors which use a length of fiber as etalon. Various configurations have been demonstrated with both monomode and graded index fiber in the etalon. Temperature stabilized laser

diodes are used with monomode fibers to couple light to the etalon fiber. Readout is via a multimode fiber and linearizing electronics. This allows tracking over many fringes of etalon deflection.

These sensors have been used to detect strain. With various coupling mechanisms, the sensors provide readouts of pressure, displacement, or magnetic field. Research is continuing on the challenges of readout stability and source module miniaturization.

Electromagnetic Waves Research Institute

Professor A.M. Scheggi and her fiber optic sensor group at Electromagnetic Waves Research Institute, Florence, Italy, were early advocates of sensors which use LED sources and multimode fibers. They have developed a number of temperature sensors, primarily with medical applications in mind. In addition to sensors, they are developing components such as couplers which are designed to optimize their fiber and system considerations. Research is primarily focused on liquid index change and on thermochromic temperature sensors.

References

Bosselman, Th., and R. Ulrich, "High-Accuracy Position Sensing With Fiber-Coupled White-Light Interferometers," in *Proceedings of the 2nd International Conference on Fiber Optic Sensors* (Stuttgart, West Germany, September 1984).

Dabkiewicz, Ph., and R. Ulrich, "Spectral Encoding for Fiber-Optic Industrial Sensors," in *Proceedings of the European Fiber Optic Communications/ Local Area Networks* (Montreux, Switzerland, 19-21 June 1985).

Gordon L. Mitchell
6/27/85

CONFERENCE ON THE BEHAVIOR OF OFFSHORE STRUCTURES

The International Conference on the Behavior of Off-shore Structures, BOSS '85, was held from 1 through 5 July at the Delft University of Technology, The Netherlands.

It was sponsored by four universities: the Norwegian Institute of Technology, the University of London, the Massachussetts Institute of Technology, and the Delft University of Technology. Participants came from many research institutions and private companies throughout the world. There were about 390 registrants from Europe, the US, and Asia. Eighty-seven papers were presented; there were five invited lectures, 57 regular lectures equally divided among three simultaneous sessions, and 25 poster papers. The proceedings have been published by Elsevier.

While the general theme centered around the effects of the environmental forces on ocean structures and the reaction of the structures to seawater and the supporting soil, this year particular emphasis was put on the integrated approach to the description, analysis, and modeling of the structures. There were many papers on the overall behavior during the design stage, the reliability of structures, and case histories and analyses of failures.

The invited papers were all very informative. E.M.Q. Røren (Norway) gave a comprehensive account of the histories and analyses of all known failures in the North Sea, Brazil, China, and elsewhere. For each case, causes were divided among design and construction deficiencies, accidental damage, maloperation, material deterioration, and corrosion. A. Veruijt (The Netherlands) gave a tutorial lecture on soil mechanics in the seabed. He combined empirical knowledge with simple theories to make the complex subject understandable to the novice. C.E. Fay (Norway) presented an up-to-date account of the design alternatives for the Troll Field in the North Sea. The Troll Field is in a 80-km-long trench west of Bergen, where the design depth is about 1000 feet. Fixed structures are found to be more appropriate than compliant or floating structures. K.R. Croasdale (Canada) lectured on ice mechanics and ice loads. His talk was richly complemented by slides of the arctic environment. M.J. Baker (UK) gave an in-depth survey of the mathematical reliability theory as applied in offshore engineering.

The regular sessions can be crudely categorized into seven areas: (1) design analysis of specific platforms; (2) hydrodynamic forces on structures, theory and experiment; (3) riser and cable dynamics; (4) soil mechanics, including pile analysis; (5) structure responses, fatigue and reliability; (6) underwater inspection and repair techniques; and (7) Arctic offshore engineering.

Quite a few papers were interesting from the scientific point of view. For example, P.W. Bearman et al. (UK and The Netherlands) reported a collaborative effort on the forces on a circular cylinder in waves. Extensive experiments were performed in a large wave tank (230-m long, 5-m wide, 7-m deep) at Delft Hydraulic Laboratory. The large

scales of the tank made it possible to obtain results in the postcritical range of Reynolds numbers (5×10^5). Also impressive was the paper on the numerical simulation of flow around circular cylinders at high Reynolds numbers, by J.J.W. van der Vegt and W.C. de Boom (The Netherlands). It is known in potential flow models that the separation point is hard to predict. They solved the Navier-Stokes equations directly and studied the flow at a Reynolds number equal to 31,700. In addition to the kinematic picture of the vortices, the drag and lift coefficients also appear to resemble their own laboratory experiments.

Chiang C. Mei
8/14/85

INTERNATIONAL SYMPOSIUM ON INFORMATION THEORY

The 1985 International Symposium on Information Theory was held from 23 through 28 June in Brighton, England. Sponsored by the Institute of Electrical and Electronics Engineers' (IEEE) Information Theory Group, the symposium provides an international forum for the exchange and discussion of advanced research results in the fields of information theory, coding, stochastic processes, networks, signal processing, and statistical communication theory. There were about 600 attendees; more than half were US citizens. Other nations with strong representation included Great Britain, France, Israel, Germany, Japan, Russia, and Yugoslavia. A volume of abstracts was provided at the symposium and is available from the IEEE under catalog number 85 CH 2201-2.

Coding

The symposium featured plenary lectures and distributed sessions of short and long papers. One of the technical highlights of the symposium was the plenary lecture given by Professor J.H. Van Lint of the Eindhoven University of Technology, The Netherlands. He described how algebraic geometry can be applied to generate a sequence of error-correcting codes that generalize the Goppa codes and exceed the Gilbert-Varshamov bound. Lint's approach exploits the fact that Goppa codes are in actuality generalized Reed-Solomon codes, to which methods and results from algebraic geometry are more easily applied. In 1982, Tsfasman, Vladut, and Zink were the first to establish the connection and apply algebraic geometry to the design of more efficient generalized codes. Their results have generated considerable excitement in the coding community and appear to be of importance comparable to those of Reed and Solomon in 1960 and Goppa in 1970.

Professor S.W. Golomb of the University of Southern California gave the honorary Shannon Lecture. He presented an overview of the development of shift register sequences. This included a discussion of the linear theory in terms of generating functions and cyclotomic cosets, and of the nonlinear theory in terms of the state diagram and the de Bruijn graph. Golomb concluded by describing current unsolved problems and areas in which shift register sequences are being applied.

Information Theory

Professor L.L. Campbell of the Queen's University, Canada, gave an interesting talk revealing connections between probability, geometry, and information measures. Regarding the positive cone in an n-dimensional vector space as a differential manifold, the Riemannian metric is shown to be the only one which satisfies a natural probabilistic invariance principle. Random variables correspond to a certain class of vector fields and, under this correspondence, means, variances, and covariances appear naturally as the inner product defined by the metric. This geometric framework leads to maximum entropy and minimum divergence probability estimates, with connections to noiseless and noisy coding. (Campbell will spend the 1985 fall semester as a visiting scholar at the Center for Stochastic Processes at the University of North Carolina, Chapel Hill.)

A.R. Barron of Stanford University spoke on the relationship between entropy and the central limit theorem. The central limit theorem states that the probability density function of the normalized sum of n independent, identically distributed random variables having finite variance converges weakly to the standard normal density. The Kullback-Leibler divergence (relative entropy) of these densities (relative to the standard normal density) converges to zero, provided it is finite for some n. The result is not surprising, but Barron's proof, which follows from fundamental properties of Shannon entropy and Fisher information and does not involve the usual Fourier transform technique, is novel. (Barron is currently completing his PhD dissertation under the direction of Professor T. Cover and has accepted a

position at the University of Illinois at Urbana-Champaign starting this fall.)

Stochastic Processes

Professor S. Cambanis of the University of North Carolina, Chapel Hill, presented some new results on discrete-time prediction of continuous-time stochastic processes obtained in collaboration with Professor E. Masry of the University of California, San Diego. Linear predictors (optimal in the Gaussian case) are considered, and the sampling scheme is formulated via a regular sampling density. The optimal sampling density and resulting minimum mean-square prediction error are derived for stationary processes with rational spectral densities. Cambanis presented numerical examples for the no and one quadratic mean derivative cases that showed an order of magnitude improvement for the optimal sampling scheme over a simplistic uniform sampling scheme. It is interesting that the concept of a regular sampling density, applied successfully here to the problem of temporal sampling for prediction, has also been successfully applied to the problem of spatial sampling for data compression, i.e., quantization.

I presented some new results regarding adaptive differential pulse-code modulation (ADPCM) of stationary Gauss-Markov sources. (DPCM is a popular scheme for the digital encoding of stochastic analog waveforms.) The stochastic stability of the system is established for the nonsaturating quantizer in the odd-level quantizer case. A Chapman-Kolmogorov equation in the form of a system of integral equations is derived for the joint distribution of the prediction error and quantizer state. This system is shown to define a bounded operator on an appropriate Hilbert space, permitting solution by Galerkin's method. Gerr's numerical results show that the asymptotic performance does not depend on the choice of initial quantizer step-size, and that the performance of adaptive DPCM approaches that of optimal fixed DPCM (for which the optimal step-size must be known a priori).

Overall Impressions

Probably the most important recent development in the areas covered at the symposium is the use of algebraic geometry to develop better error-correcting codes. It appears that Europe (and the USSR) have led the way in this advancement. Good work in the areas of information theory and stochastic processes is being performed in the US, France, and the USSR. There appears to have been substantial growth in the areas of queuing theory and networks, which relate to computer and communication systems, and spread-spectrum communications, which yields antijamming and low-probability-of-intercept capabilities in a hostile military environment.

Neil L. Gerr
8/5/85

AEG-TELEFUNKEN MAKES IMPRESSIVE ADVANCES IN OPTICAL MULTIPLEXING TECHNIQUES

Professor O. Krumpholz and his graduate student coworkers at the Department of Optical Communications Technology of AEG-Telefunken Research Institute, Ulm, West Germany, recently reported substantial progress in their work on the design and prototype manufacture of a hybrid integrated duplexer. (This research is being done in cooperation with the firm ANT Nachrichtentechnik GmbH and is supported by the Federal Ministry for Research and Technology.)

Wavelength division multiplexing results in more efficient utilization of the optical fiber connections. The AEG-Telefunken Research Institute developed components for coupling/decoupling and separating different carrier frequencies for duplex or multiplex operation, which are designed for use in optical systems with graded index fibers.

To allow for manufacturing the components in large numbers and at low cost, the researchers developed an advanced concept incorporating the transmitter and receiver elements, thus eliminating both the need for separate housings for these components as well as several steps of assembly and adjustment. Optical, optoelectronic, and electrical components have been integrated into a single assembly, called a "hybrid integrated duplexer." The principle of this novel device is illustrated in Figure 1.

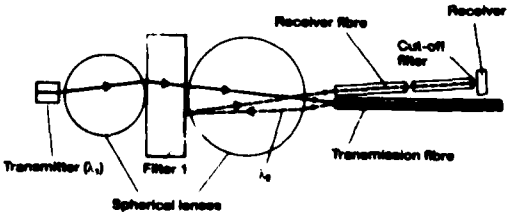

Figure 1. Concept of the hybrid duplexer.

In this system, the light output (wavelength λ_1) from the optical transmitter is coupled into the transmission fiber by two spherical lenses. The light signal with wavelength λ_2, arriving in this fiber from the distant "subscriber" at the second spherical lens, is reflected by an interference filter (a glass plate between the two lenses) and is guided to the detector by a short fiber section which acts as a stop for stray light. The micro-optical elements are positioned with the aid of embossed grooves. The complete, very small assembly has only one optical connection, in addition to the electrical connections for the transmitter diode and detector. Actually, the electronic circuits which drive the diode and amplify the detector signal can also be integrated in this structure. One additional, special merit of the device is that the usual losses caused by a separate duplexer are eliminated.

Duplexers can also be operated as two-channel multiplexers. But in this case, reflection diffraction gratings are needed to separate wavelengths. The Ulm group also produced very efficient multiplexers of this kind, using a diffraction grating with a groove spacing of only 3.5 μm; the grating was made of specially oriented silicon wafers, etched anisotropically. A diffraction efficiency up to 90 percent has been achieved. Reversing the beam direction, the same device can act as a grating demultiplexer.

All components of the systems mentioned above have been subjected to comprehensive tests, and the results were unexpectedly encouraging. For example, at temperatures between -20°C and +60°C, the insertion loss changed by less than a few tenths of a decibel. Several hundred devices already have been fabricated and are undergoing testing in large, practical communications systems.

Paul Roman
8/5/85

"MEETING WITH SCIENCE"--AN UNUSUAL CONFERENCE

Private enterprise was the motivating force behind a 1-day conference held on 22 July in Dornbirn, a city in the westernmost corner of Austria on the border with West Germany, Switzerland, and Liechtenstein.

The purpose of the symposium was to demonstrate for a regional and local audience of managers, technologists, and entrepreneurs some effects of scientific research on economy and society. Six scientists from Austria, West Germany, Switzerland, and the US gave 50-minute-long talks on selected topics, ranging from a comparison of the European and American science-education systems to models of industry-university cooperation in high-technology development. The emphasis was on impressing the potential leaders of a technically undeveloped area with an analysis of the challenges and possibilities rendered feasible by the "scientific advanture" of our age and by the ever-increasing mutual reliance of allied nations. The audience of about 250 engaged the speakers in lively discussions that centered on specific problems of a harmonious development of the region's technology.

As one of the six speakers, I sketched the history and structure of the US Office of Naval Research, and explained the role that the London branch plays in knowledge-exchange activities with European scientists and with research and development centers.

Paul Roman
8/15/85

ESPRIT PROGRAM TO BUILD EUROPEAN SUPERCOMPUTER

The European Economic Community's ESPRIT program for funding information technology research has announced an award of a contract to build a European supercomputer. The prime contractor for the £5.7 million project is the UK's Royal Signals and Radar Research Establishment.

Also participating in the contract will be INMOS, Thorn EMI, the University of Southampton, and three French organizations, Telmat, Apsis, and Grenoble University.

The architecture of the new computer will be that of the system developed at Southampton University under the direction of Dr. Christopher Jesshope (see *ESN* 39-6:252-255 [1985]). It will be a multiprocessor architecture using INMOS's 32-bit Transputers. It is expected to be completed in 2 years.

J.F. Blackburn
8/12/85

UK PANEL REVIEWS MATHEMATICS CURRICULUM FROM 5 TO 16

The teaching of mathematics has been a subject of considerable debate for a number of years both in the UK as well as in the US. The UK's Department of Education and Science recently published a discussion document, *Mathematics from 5 to 16*, which considers both the aims and objectives of mathematics teaching for students aged 5 to 16 and implications for the choice of content, the classroom approaches, and the assessment of students' performance.

Mathematics is a difficult subject both to teach and to learn; the goal of the report is to suggest approaches to make the teaching and learning of mathematics a more rewarding experience for both teachers and students. To this end, the report considers that mathematics should be shown to be an essential element of communication and a powerful tool for problem solving rather than a series of miscellaneous facts to be learned.

The document does not analyze ways to ensure that there is a steady flow of qualified teachers who understand the importance of mathematics. This appears to be a serious problem in the US.

Copies of this document are available from Her Majesty's Stationery Office (HMSO) at a price of £2.00. A more comprehensive document, published in 1982, is *Mathematics Counts*, also available from HMSO at a price of £6.95.

Charles J. Holland
7/8/85

GBF AND INDUSTRY COOPERATE IN WEST GERMANY

The GBF (Institute for Biotechnological Research Ltd.) of Braunschweig, West Germany, was originally founded as a molecular biology institute by academics, with the support of the Volkswagenwerk Foundation. It has recently been expanded as a national research center with funds allocated by the federal government and the State of Lower Saxony, where Braunschweig is located.

The GBF is charged with cooperating with both industry and universities, without becoming a mere extension of either. Thus the aim is to promote external research and, above all, to foster industrial innovative potential by enhancing research and accelerating the exploitation of research results. The GBF exists not only because of its own work, but because of its contacts with universities, industry, and other national and international institutions. The most important area is the contractural agreement on cooperation in fields of joint interest--for example, when the market activities of a commercial enterprise or the research activities of an industrial company match the GBF research and development program (R&D) and offer the possibility of an integrated approach. This type of cooperation is especially important since the final and effective user of GBF's "know-how" is directly involved in the cooperative arrangement. It also enables smoother potential transfer of GBF staff with specific know-how. However, if the GBF has already developed a particular expertise or owns a copyright, it is active in locating suitable licencees both in and outside Germany.

In addition to these cooperative agreements on individual R&D tasks, additional possibilities exist for the streamlined transfer of know-how. The GBF has therefore created a number of ways to inform industry of the successful work being performed:

1. Staff delegation to and takeover of GBF personnel by industry.
2. Postdoctoral programs and integration of guest researchers.
3. Expertise exchange agreements.
4. Consulting agreements.
5. Awarding of contracts for the installation of pilot plants and equipment according to GBF specifications.
6. Joint installation and operation of pilot facilities.

The GBF has also instituted several modes of promotion that are of particular value to small and medium-size companies:

1. Industrial forums and conferences.
2. Advertising in specialist and trade magazines, information bulletins.
3. Advertising at technology fairs.
4. Storage of information in technology transfer data banks.
5. Seminars.

The GBF or Biotechnum represents a special service to industry where the following work is performed at cost:

1. Scientific and technical service provided by the production of natural products, cell cultures, and enzymes which are not commercially available.
2. Contractual research for industry (on a small scale).

The GBF has already concluded about 50 know-how and licensing agreements. A few examples of GBF cooperation with

industry and academia are: (1) German collection of microorganisms (DSM), an internationally recognized deposit for patent strains; (2) provision of microorganisms for research and industry; (3) process innovations--e.g., two-phase system and the development of new concepts for the enzymatic synthesis of amino acids, including enzymatic co-enzyme regeneration in membrane reactors; (4) cosmid cloning techniques; (5) product innovations--e.g., restriction enzymes, penicillin acylase, and oligonucleotides (successfully marketed); (6) production of interferon in cooperation with Bioferm, an industrial partner. The GBF is also exploiting engineering developments, processes, and products based on enzyme engineering and genetics as well as research and service provisions in the areas of fermentation, analysis, and measuring techniques.

Claire E. Zomzely-Neurath
8/19/85

INDUSTRIAL PRODUCTION OF MONOCLONAL ANTIBODIES UNDER WAY AT UK FIRM

The use of monoclonal antibodies in research and diagnostic applications has increased dramatically over the last few years. Increasing interest is now being shown in areas such as immunotherapy and immunopurification. These applications require production methods capable of producing large quantities of antibody (many kilograms in some cases).

Monoclonal antibodies have typically been produced by growing hybridoma cells in animals or in small-scale culture systems such as roller bottles. Neither technique can be readily scaled up. However, Celltech Ltd. of Slough, UK, has recently developed a homogeneous fermentation system based on the airlift principle. Vessels ranging in size from 5 to 1000 L working volume are used. Thus far, 23 different antibody-producing cell lines of human, mouse, and rat origin have been grown in these fermenters.

While antibody levels in conventional small-scale cultures typically reach volumes of 10 to 100 mg/L, optimization of fermentation conditions has led to production levels in the range of 40 to 500 mg/L in Celltech's production system. Scale-up was found to be predictable in that growth kinetics and antibody production are similar at the various scales used. In addition to batch fermentation, which forms the basis of their current production process, Celltech is also examining continuous chemostat culture, both to study the regulation of antibody synthesis and as a potential production process.

Claire E. Zomzely-Neurath
8/19/85

PILOT PLANT FOR MONOCLONAL ANTIBODY PRODUCTION

Boehringer Mannheim Co., West Germany, plans a pilot plant for industrial production of monoclonal antibodies for therapeutic use. The 5-year research project using hybridoma techniques will receive government support from the Federal Ministry of Research and Technology in the amount of DM5.8 million (about $1.7 million).

Boehringer will be cooperating in this project with the universities of Munich and Heidelberg. The company will use a patented process to obtain hybrid cells which produce antibodies in permanent cultures. For production, Boehringer will use a capillary modular bioreactor with hollow fibers.

Claire E. Zomzely-Neurath
8/19/85

NEW GENE TECHNOLOGY RESEARCH GROUPS AT MPI, WEST GERMANY

Three independent gene technological research groups are being established in the following areas at the Max Planck Institute in Martinsreid, Munich, West Germany:

1. Microsequencing of proteins and biologically active peptides with emphasis on gas phase sequencing.
2. Molecular embryology, emphasizing early mammalian development.
3. Transcription (gene expression) in eucaryotes--mechanisms and controls, emphasizing differentiation.

The Max Planck Institutes for Biochemistry and Psychiatry--together with the gene center at the University of Munich, supported by industry--are setting up new research divisions in gene technology research. Each group will have about 150 m^2 of laboratory space, positions for scientific and technical

assistance, and appropriate financial support for equipment and running costs. Contracts with the heads of the teams will be guaranteed for 5 years. The new research positions are available to non-German scientists as well as to German nationals.

Claire E. Zomzely-Neurath
8/19/85

UNITED KINGDOM SEEKS BIOTECH INVESTMENTS

A campaign to attract to Britain biotechnology companies seeking to manufacture genetically engineered products and other innovations has been launched by the Department of Trade and Industry (DTI). The department's biotechnology unit in London is spearheading the campaign to find new manufacturing opportunities among overseas companies that might be assisted by the department's aid for innovation. Genetics International, a US company, has already been helped to set up production of novel sensors and biosensors in Britain.

The more successful of the small biotechnology research companies launched in the past few years, especially in the US, have begun to seek manufacturing outlets in Europe. The DTI group is also trying to attract to Britain larger international companies with new biotechnology products. The DTI's biotechnology unit believes that Britain can make a good case, partly because it has a less complicated regulatory system for new health-care products, compared with many other European countries. G.D. Searle and Eli Lily of the US, for example, have already developed and launched genetically engineered products in Britain. Another attraction to companies is the strong scientific base provided by British industries and government laboratories.

The department's biotechnology unit, set up 2 years ago as a "think tank," has on its staff industrial scientists backed by companies such as Imperial Chemical Industries, British Petroleum, and Glaxco. So far, it has approved the $6.6 million investment on 67 projects proposed by companies in Britain. About $2.5 million was spent in 1984-85, and the spending is expected to increase further.

One area of biotechnology investment being reconsidered by the DTI unit is waste treatment, where it has invested in three new British pilot plants and 20 consultancies at a cost of $190,000.

Claire E. Zomzely-Neurath
8/20/85

CHEMISTS AT UNIVERSITY COLLEGE LONDON WIN SERC GRANTS

The Chemistry Department of University College London has announced that the Science and Engineering Research Council (SERC) has made awards to four faculty members. The new research grants are over 2 years for work on:

- "The speed of sound in pure fluids near the critical state," by Dr. Ewing (£27,329).
- "Oxygen-centered radical cations," by Professor Davies (£26,150).
- "The organic chemistry of ligated boranes," by Dr. Roberts (£26,150).
- "Synthetic, spectroscopic, and structural studies on one-dimensional semiconductors," by Professor Clark (£26,150).

David L. Venezky
8/5/85

NATO SYMPOSIUM ON THE TRANSFER OF TRAINING TO MILITARY OPERATIONAL SYSTEMS

A North Atlantic Treaty Organization (NATO) Symposium on the Transfer of Training to Military Operational Systems was held at NATO Headquarters, Brussels, from 7 through 9 October 1985. The purpose was to: (1) report data documenting effective transfer of skills and knowledge from training environments to the operational and maintenance environments of military systems, (2) indicate the use of such data in improved training and equipment design, and (3) identify areas where current knowledge and technology need expansion. For information on proceedings, contact Dr. Joseph D. Hagman, Army Research Institute, 5001 Eisenhower Avenue, Alexandria, Virginia 22333.

Richard E. Snow
8/7/85

ONRL COSPONSORED CONFERENCES

ONR, London, can nominate two registration-free participants in the conferences it supports. Readers who are interested in attending a conference should write to the Scientific Director, Office of Naval Research Branch Office, Box 39, FPO New York 09510-0700.

The Third Israel Materials Engineering Conference, Technion City, Haifa, Israel, 10-11 December 1985.

New Technological Applications of Phospholipid Bilayers, Films, and Vesicles, Puerto de la Cruz (Tenerife), Canary Islands, 6-9 January 1986.

SCIENCE NEWSBRIEFS FOR AUGUST

The following issues of *Science Newsbrief* were published by the ONR, London, Scientific Liaison Division during August. *Science Newsbrief* provides concise accounts of scientific developments or science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

Science Newsbrief Number	Title
3-41	Wide-Tuning-Range Infrared Waveguide Laser Developed in Frankfurt, by Paul Roman.
3-42	French Scientists Design a Pioneering Optical Satellite Link, by Paul Roman.
3-43	Sweden to Host Workshop on Adaptive Systems, by Charles Holland.
3-44	INRIA to Sponsor Conference on Systems Analysis and Optimization, by Charles Holland.
3-45	Wavelength Encoded Optical Fiber Sensors Developed at NPL, by Paul Roman.

JULY AND AUGUST MAS BULLETINS

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during July and August. The *MAS Bulletin* is an account of naval developments in European research, development, test, and evaluation. Its distribution is limited to offices with the US Department of Defense. DoD organizations should request copies of the *Bulletins*, by number, from ONR, London.

MASB Number	Title
84-85	Infrared Passive Detection and Tracking Systems from Hollandse Signaalapparaten
85-85	New Support Aircraft Carriers for the NATO Navies
86-85	Dutch Minehunters
87-85	French Acoustic Television Development
88-85	Third International Meeting on Coherent Laser Radar Technology and Applications
89-85	European Aerospace Update
90-85	The French Experimental Fighter Demonstrator Aircraft--Rafale
91-85	Side Scan Sonar Probes the Bottom of a Channel
92-85	French National Oceanographic Data Center
93-85	French Oceanography--Technology and Science in Brest, France
94-85	Oceanographic Remote Sensing, Atmospheric Forcing and Modelling: Two UK Meetings in September/October
95-85	Type 23 Frigate Batch II
96-85	Wire Sweep Monitoring Equipment
97-85	Royal Navy Amphibious Force Concept Design
98-85	Coastal Defense and Assault Vessel and Systems Call for Papers
99-85	Seawolf
100-85	Self-Propelled Hyperbaric Lifeboat
101-85	German Mine Countermeasures Vessel Program
102-85	UK Experimental Aircraft Program

ONR REPORTS

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R-3-85 *Biomaterials Research in West Germany--An Assessment*, by Thomas C. Rozzell. West Germany is one of the leading countries in Europe for research in biomaterials. Researchers have developed a number of new techniques

and methods utilizing a wide range of synthetic and natural materials for use in medicine. Exotic ceramics, metals, and plastics are being used both in animals and in humans for such things as tissue repair, wound coverings, drug delivery, and prostheses. The West German scientists, bioengineers, and clinicians are very aggressive in attacking new problems related to the use of biomaterials in therapy.

R-4-85 *Biological Sciences and Bioelectromagnetics in Europe: Summary Report*, by Thomas C. Rozzell. This report examines in detail bioelectromagnetics research in Europe and provides an overview of several aspects of general biomedical, biomaterials, and biotechnological research.

R-5-85 *Hydroacoustics Research in Europe*, by Patrick Leehey. Hydroacoustics research is vigorous in Europe. Particularly the work in France and England overshadows that being done in the US. It appears that much more experimental work is needed to test the overwhelming amount of theory.

C-7-85 *Laser 85: Optoelektronik*, by Paul Roman. The "Laser 85: Optoelektronik" international congress and trade fair drew several thousand scientists, engineers, and technologists to Munich, West Germany, from 1 through 5 July 1985. This report focuses on research paper presentations dealing with lasers and laser systems, and with lasers and optoelectronics in space technology. It also lists the topics of all sessions and the subject areas of the exhibition.

C-8-85 *The Alvey Conference in Edinburgh: A Review of the UK's Research Program in Computer Science*, by J.F. Blackburn. A conference to review the UK's Alvey Program of research in computer science was held in Edinburgh from 24 through 27 June 1985. This report summarizes the speakers' comments about the progress of the Alvey Program.

C-9-85 *The 21st International Symposium on Applied Military Psychology*, by Richard E. Snow. The symposium contained presentations on research on selection and utilization of personnel, basic measurement problems, personal and social aspects of military training and performance, coping with stress, panic and collective behavior, recruitment and retention, and special research topics for the future.

C-10-85 *10th Meeting of the International Society for Neurochemistry*, by Claire Zomzely-Neurath. The tenth meeting of the International Society for Neurochemistry was held in Riva del Garda, Italy, from 19 through 24 May 1985. This report discusses presentations on molecular neurobiology, post-translational modification, neurotransmitter receptors, neuropeptide processing, and specific macromolecules in cell-cell interactions in the nervous system.

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